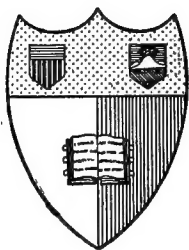


THE U.S.GEOLOGICAL SURVEY

SERVICE MONOGRAPHS
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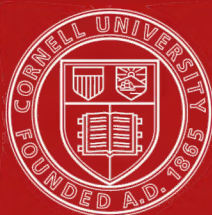
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**THE U. S. GEOLOGICAL SURVEY,
ITS HISTORY, ACTIVITIES
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No. 1

THE U. S. GEOLOGICAL SURVEY

ITS HISTORY, ACTIVITIES
AND ORGANIZATION



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THE INSTITUTE FOR GOVERNMENT RESEARCH

Washington, D. C.

The Institute for Government Research is an association of citizens for coöperating with public officials in the scientific study of administrative methods with a view to promoting efficiency in government and advancing the science of administration. It aims to bring into existence such information and materials as will aid in the formation of public opinion, and will assist officials, particularly those of the national government, in their efforts to put the public administration upon a more efficient basis.

To this end, it seeks by the thoroughgoing study and examination of the best administrative practice, public and private, American and foreign, to formulate those principles which lie at the basis of all sound administration, and to determine their proper adaptation to the specific needs of our public administration.

The accomplishment of specific reforms the Institute recognizes to be the task of those who are charged with the responsibility of legislation and administration; but it seeks to assist, by scientific study and research, in laying a solid foundation of information and experience upon which such reforms may be successfully built.

While some of the Institute's studies find application only in the form of practical coöperation with the administrative officers directly concerned, many are of interest to other administrators and of general educational value. The results of such studies the Institute purposes to publish in such form as will insure for them the widest possible utilization.

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FOREWORD

The first essential to efficient administration of any enterprise is full knowledge of its present make-up and operation. Without full and complete information before them, as to existing organization, personnel, plant, and methods of operation and control, neither legislators nor administrators can properly perform their functions.

The greater the work, the more varied the activities engaged in, and the more complex the organization employed, the more imperative becomes the necessity that this information shall be available—and available in such a form that it can readily be utilized.

Of all undertakings, none in the United States, and few, if any, in the world, approach in magnitude, complexity, and importance that of the national government of the United States. As President Taft expressed it in his message to Congress of January 17, 1912, in referring to the inquiry being made under his direction into the efficiency and economy of the methods of prosecuting public business, the activities of the national government "are almost as varied as those of the entire business world. The operations of the government affect the interest of every person living within the jurisdiction of the United States. Its organization embraces stations and centers of work located in every city and in many local subdivisions of the country. Its gross expenditures amount to nearly \$1,000,000,000 annually. Including the personnel of the military and naval establishments, more than 400,000 persons are required to do the work imposed by law upon the executive branch of the government.

"This vast organization has never been studied in detail as one piece of administrative mechanism. Never have the

foundations been laid for a thorough consideration of the relations of all of its parts. No comprehensive effort has been made to list its multifarious activities or to group them in such a way as to present a clear picture of what the government is doing. Never has a complete description been given of the agencies through which these activities are performed. At no time has the attempt been made to study all of these activities and agencies with a view to the assignment of each activity to the agency best fitted for its performance, to the avoidance of duplication of plant and work, to the integration of all administrative agencies of the government, so far as may be practicable, into a unified organization for the most effective and economical dispatch of public business."

To lay the basis for such a comprehensive study of the organization and operations of the national government as President Taft outlines, the Institute for Government Research has undertaken the preparation of a series of monographs, of which the present study is one, giving a detailed description of each of the fifty or more distinct services of the government. These studies are being vigorously prosecuted, and it is hoped that all services of the government will be covered in a comparatively brief space of time. Thereafter, revisions of the monographs will be made from time to time as need arises, to the end that they may, as far as is practicable, represent current conditions.

These monographs are all prepared according to a uniform plan. They give: first, the history of the establishment and development of the service; second, its functions, described not in general terms, but by detailing its specific activities; third, its organization for the handling of these activities; fourth, the character of its plant; fifth, a compilation of, or reference to, the laws and regulations governing its operations; sixth, financial statements showing its appropriations, expenditures and other data for a period of years; and finally, a full bibliography of the sources of information, official and private, bearing on the service and its operations.

In the preparation of these monographs the Institute has kept steadily in mind the aim to produce documents that will be of direct value and assistance in the administration of public affairs. To executive officials they offer valuable tools of administration. Through them, such officers can, with a minimum of effort, inform themselves regarding the details, not only of their own services, but of others with whose facilities, activities and methods it is desirable that they should be familiar. Under present conditions services frequently engage in activities in ignorance of the fact that the work projected has already been done, or is in process of execution by other services. Many cases exist where one service could make effective use of the organization, plant or results of other services had they knowledge that such facilities were in existence. With the constant shifting of directing personnel that takes place in the administrative branch of the national government, the existence of means by which incoming officials may thus readily secure information regarding their own and other services is a matter of great importance.

To members of Congress the monograph should prove of no less value. At present these officials are called upon to legislate and appropriate money for services concerning whose needs and real problems they can secure but imperfect information. That the possession by each member of a set of monographs, such as is here projected, prepared according to a uniform plan, will be a great aid to intelligent legislation and appropriation of funds can hardly be questioned.

To the public, finally, these monographs will give that knowledge of the organization and operations of their government which must be had if an enlightened public opinion is to be brought to bear upon the conduct of governmental affairs.

These studies are wholly descriptive in character. No attempt is made in them to subject the conditions described to criticism, nor to indicate features in respect to which changes might with advantage be made. Upon administrators themselves falls responsibility for making or proposing changes

which will result in the improvement of methods of administration. The primary aim of outside agencies should be to emphasize this responsibility and facilitate its fulfillment.

While the monographs thus make no direct recommendations for improvement, they cannot fail greatly to stimulate efforts in that direction. Prepared as they are according to a uniform plan, and setting forth as they do the activities, plant, organization, personnel and laws governing the several services of the government, they will automatically, as it were, reveal, for example, the extent to which work in the same field is being performed by different services, and thus furnish the information that is essential to a consideration of the great question of the better distribution and coördination of activities among the several departments, establishments and bureaus, and the elimination of duplications of plant, organization and work. Through them it will also be possible to subject any particular feature of the administrative work of the government to exhaustive study, to determine, for example, what facilities, in the way of laboratories and other plant and equipment, exist for the prosecution of any line of work and where those facilities are located; or what work is being done in any field of administration or research, such as the promotion, protection and regulation of the maritime interests of the country, the planning and execution of works of an engineering character, or the collection, compilation and publication of statistical data, or what differences of practice prevail in respect to organization, classification, appointment, and promotion of personnel.

To recapitulate, the monographs will serve the double purpose of furnishing an essential tool for efficient legislation, administration and popular control, and of laying the basis for critical and constructive work on the part of those upon whom responsibility for such work primarily rests.

Whenever possible the language of official statements or reports has been employed, and it has not been practicable in all cases to make specific indication of the language so quoted.

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THE U. S. GEOLOGICAL SURVEY: ITS HISTORY, ACTIVITIES AND ORGANIZATION

CHAPTER I

HISTORY

The United States Geological Survey, a bureau of the Department of the Interior, is engaged chiefly in surveying the geology, topography, and related features of the United States and in publishing the results of its surveys and investigations.

Early Explorations and Surveys of the Public Domain: 1804-1865. Previous to the establishment of the Geological Survey, the surveys conducted by the national government were chiefly exploratory in character, and were, therefore, confined almost wholly to the western country. Numerous surveys were made at an early date, most of them by the Army, partly for military use and partly to extend geographical knowledge. The most important was the Lewis and Clark Expedition of 1804-1806, which ascended the Missouri to its sources and then descended the Columbia to the Pacific. The expeditions of Pike in 1805 and 1807 to the sources of the Mississippi and the Arkansas were also of prime importance. In 1820 an important expedition in Upper Michigan, Wisconsin and Minnesota was conducted by General Cass, then Superintendent of Indian Affairs; and in 1832 an expedition to one of the sources of the Mississippi was made by Schoolcraft, the famous student of Indian life, while traveling in behalf of the Bureau of Indian Affairs.

While as early as 1820 General Cass had taken a mineralogist with him, it was not until 1834 that Congress made a specific appropriation for geological surveys. The act of June 28, 1834, appropriated \$5,000 "to be applied to geological and mineralogical survey and researches." This appropriation was used in making a geological survey of the country between the Missouri River and the Red River, and the resulting report contained, in addition to an account of the geology and mineralogy of the areas covered, a geologic section of the country from the New Jersey coast to the Red River in Texas.

In the period from 1835 to 1850 the surveys and explorations made in the western country under Army auspices rapidly increased in number. Of these perhaps the most noteworthy were those of Captain, later General Fremont. Of the civilian surveys of the period, those made by David Dale Owen, beginning in 1839, under the auspices of the General Land Office, were of great importance, embracing as they did the geology of the region now included in the states of Illinois, Iowa, Wisconsin and Minnesota.

During 1853-1861 the War Department, under authority of the act of March 3, 1853 (10 Stat. L., 219) and supplementary acts, made surveys for a railroad from the Mississippi River to the Pacific Ocean, geologists accompanying each of the field parties. The investigations made were reported in thirteen quarto volumes, published in 1855-1860 under the title, "Reports of explorations and surveys to ascertain the most practicable and economical route for a railroad from the Mississippi River to the Pacific Ocean."

During the Civil War and for a year or more thereafter no government survey of note appears to have been undertaken.

Geographical and Geological Surveys: 1867-1879. With the close of the war the work of surveying and mapping the western country was renewed with increased vigor. Between 1867 and 1869 four surveying expeditions were put in the

field, two by the War Department and two by the Department of the Interior, as follows:

1. *Geological Exploration of the Fortieth Parallel.* The act of March 2, 1867 (14 Stat. L., 457) provided for "a geological and topographical exploration of the territory between the Rocky Mountains and the Sierra Nevada Mountains, including the route or routes of the Pacific Railroad." This survey was made under the jurisdiction of the War Department but its director, Clarence King, was a civilian, as were also all his scientific assistants. The territory surveyed comprised a belt 105 miles in width extending from longitude $104^{\circ} 30'$ to longitude 120° ,—that is, from Cheyenne, Wyoming, to the eastern boundary of California. The survey was primarily geological in character but included also the topography of the region. The results of the survey were published in 1870-1880 in seven volumes and an atlas. The total cost of the survey and its publications was \$383,711.

2. *Geological and Geographical Survey of the Territories.* The act of March 2, 1867 (14 Stat. L., 471, sec. 2) called for "a geological survey of Nebraska, said survey to be prosecuted under the direction of the Commissioner of the General Land Office." F. V. Hayden was assigned to this work and was subsequently designated United States geologist for the territories of Colorado and New Mexico. As the work progressed, its scope was by authority of Congress extended over all the territories and work was done in Wyoming, Idaho, Montana, New Mexico and Colorado, the total area embraced in systematic surveys reaching about 100,000 square miles. This survey was primarily geological, but its activities included work on topography, geology, paleontology, ethnology, philology, botany and kindred sciences. The results were published in a series of volumes which were issued from 1867 to 1883.¹

¹ The titles of the reports for 1867-1872 do not contain the word "geographical;" those for 1873-1878 do contain that word. The titles of the bulletins read: Bulletin of the United States Geological and Geographical Survey of the Territories.

The original appropriation for this survey was only \$5,000, but this was increased by successive annual appropriations of \$10,000, \$25,000, \$50,000, \$75,000, \$115,000, \$110,000, \$95,000, \$65,000, \$75,000 and \$75,000, as well as by a specific appropriation of \$30,000 to complete maps and office work; so that the total cost of the survey amounted to \$735,000 exclusive of the cost of printing and engraving and of the services of several officers detailed from the Army.

3. *Geographical and Geological Survey of the Rocky Mountain Region.* In 1867 the Smithsonian Institution began an exploration of the Colorado River. This survey was later recognized by Congress in a joint resolution, approved July 11, 1868 (15 Stat. L., 253), authorizing the Secretary of War "to issue rations for twenty-five men of the expedition engaged in the exploration of the river Colorado under direction of Professor Powell, while engaged in that work." Additional appropriations, \$54,000 in all, were granted in 1870-73, the expedition still remaining under the control of the Smithsonian Institution. On the completion of the survey of the Colorado River, Powell was, by act of June 23, 1874 (18 Stat. L., 207), authorized to continue the survey in Utah under the direction of the Secretary of the Interior; and subsequent acts of appropriation authorized the extension of the field of survey to the "Rocky Mountain region." In all, the area surveyed was 67,000 square miles, embracing southern Wyoming, central and southern Utah and adjacent portions of Nevada and Arizona. This survey was primarily exploratory and geographical but, in addition to the triangulation of the whole region and the establishment of the geodetic points, it included work in topography, ethnology, geology, botany, paleontology and kindred sciences.

The results of the survey were not published in full, the only printed documents produced being two brief reports in 1877 and 1878 by Powell.

Though the appropriations for the survey amounted only

to \$244,000, the total cost, not including engraving and printing, as stated by Powell in a letter to the Secretary of the Interior, was \$279,000.

4. *Geographical Survey West of the One Hundredth Meridian*. An act approved June 10, 1872 (17 Stat. L., 367) authorized a "continuance of military and geographical surveys and explorations west of the one hundredth meridian of longitude." The survey was made under the jurisdiction of the War Department, Lieutenant George M. Wheeler, of the Engineer Corps, being placed in charge. This survey, as its name implies, covered all the territory west of the one hundredth meridian, which includes the western parts of the Dakotas, Nebraska, Kansas and Texas, the Rocky Mountain states, and the Pacific Coast states. This survey was primarily geographical or topographical, but, as was stated in the report of the Chief of Engineers to the Secretary of War on May 10, 1878 (House Executive Document No. 88, 45th Congress, 2d Session), was so made as to obtain "at the same time and as far as practicable without greatly increasing the cost, all the information necessary before the settlement of the country, concerning the branches of mineralogy and mining, geology, paleontology, zoology, botany, archæology, ethnology, philology, and ruins."

The survey was brought to a close in 1879 and its results were published in 1875-1889 under varying titles.²

The original appropriation for this survey was \$75,000, but a series of additional appropriations for continuing the survey, for engraving and printing, and for completing the office work of the survey brought the total direct appropriations for the survey up to the sum of \$618,644. If to this sum is added the value of the aid and supplies received from the War Department and the salaries of regular Army officers detailed

² The titles of these reports and of the papers they contain are given in Bulletin 222 of the U. S. Geological Survey.

to the survey, the cost of the survey appears to have been \$805,340.³

Establishment of the U. S. Geological Survey, 1879. It will thus be seen that in the early seventies four surveys were simultaneously in progress under specific appropriations made by Congress, two under the Interior Department and two under the War Department, each having a method of its own and in several places two covering the same area.

In addition, the Coast and Geodetic Survey, after having executed a triangulation and detailed survey of part of the coast of the United States, had, under authority granted by Congress in the act of March 3, 1871, extended its work into the interior in order to provide, by means of primary triangulation carried across the continent, geodetic connection between the Atlantic and Pacific Coasts.

The feeling became very strong, both in Congress and outside, that this condition of affairs was unsatisfactory, for there was evidently not only loss of efficiency and unnecessary expense by having five separate organizations working in the same general field, but duplication and overlap of work.⁴

As a result, in 1878, Congress in making further appropriations for the existing surveys (act of June 20, 1878, 20 Stat. L., 230) provided that:

The National Academy of Sciences is hereby required, at their next meeting, to take into consideration the methods and expenses of conducting all surveys of a scientific character under the War or Interior Department, and the surveys of the Land Office, and to report to Congress as soon thereafter as may be practicable a plan for surveying and mapping the Territories of the United States on such general system as will, in their judgment, secure the best results at the least possible cost; and also to recommend to Congress a suitable plan for

³ A full discussion of the indirect cost of this survey may be found in the report of the commission to consider the organization of the Signal Service, Geological Survey, etc., 1886. (Senate Report No. 1285, 40th Congress, 1st Session.)

⁴ See H. R. Report No. 612, 43d Congress, 1st Session.

the publication and distribution of the reports, maps, and documents, and other results of said surveys.

The National Academy submitted its report to the House of Representatives on December 3, 1878 (House Executive Document No. 5, 45th Congress, 3d Session). In this report the academy, after briefly discussing the systems of survey then existing, recommended that the Coast and Geodetic Survey be transferred from the Treasury to the Interior Department and there take over all surveys of mensuration, including those being performed by the four surveys heretofore enumerated, as well as the work performed by the surveyors of the General Land Office. The report proceeds to state that:

The best interests of the public domain require, for the purposes of intelligent administration, a thorough knowledge of its geological structure, natural resources, and products. The domain embraces a vast mineral wealth in its soils, metals, salines, stones, clays, etc. To meet the requirements of existing laws in the disposition of the agricultural, mineral, pastoral, timber, desert, and swamp lands, a thorough investigation and classification of the acreage of the public domain is imperatively demanded. The committee, therefore, recommend that Congress establish, under the Department of the Interior, an independent organization, to be known as the United States Geological Survey, to be charged with the study of the geological structure and economical resources of the public domain, such survey to be placed under a Director, who shall be appointed by the President, and who shall report directly to the Secretary of the Interior.

The recommendations of this report were incorporated in the legislative, executive and judicial appropriation bill, and in this form favorably acted upon by the House, but in the Senate, owing to the congestion of business at the close of the session, and for other reasons not connected with the merits of the matter, these provisions failed of passage. In the resulting conference committee the provisions intended to con-

solidate all surveys of mensuration in a single service to be organized around the Coast and Geodetic Survey were dropped, but the following was agreed on for insertion in the sundry civil appropriation bill:

For the salary of the Director of the Geological Survey, which office is hereby established, under the Interior Department, who shall be appointed by the President, by and with the advice and consent of the Senate, \$6,000; provided, that this officer shall have the direction of the Geological Survey,⁵ and the classification of the public lands and examination of the Geological Structure,⁵ mineral resources, and products of the national domain, and that the Director and members of the Geological Survey shall have no personal or private interests in the lands or mineral wealth of the region under survey, and shall execute no surveys or examinations for private parties or corporations; and the geological and geographical survey of the Territories, and the geographical and geological survey of the Rocky Mountain region, under the Department of the Interior, and the geographical surveys west of the one hundredth meridian, under the War Department, are hereby discontinued, to take effect on the 30th day of June, 1879. And all collections of rocks, minerals, soils, fossils, and objects of natural history, archæology, and ethnology, made by the Coast and Interior Survey, the Geological Survey, or by any other parties for the Government of the United States, when no longer needed for investigations in progress, shall be deposited in the National Museum.

For the expenses of the Geological Survey and the classification of the public lands and examination of the geological structure, mineral resources and products of the national domain, to be expended under the direction of the Secretary of the Interior, \$100,000. * * *

The publications of the Geological Survey shall consist of the annual report of operations, geological and economic maps illustrating the resources and classification of the lands, and reports upon general and economic geology and paleontology. The annual report of operations of the Geological Survey shall accompany the annual report of the Secretary of the Interior. All special memoirs and reports of said Survey shall be issued

⁵ The capitalization of these words, which appears in the Statutes (Vol. 20, p. 394), is doubtless a typographical error.

in uniform quarto series if deemed necessary by the Director, but otherwise in ordinary octavos.

On March 3, 1879, the bill containing these provisions became law (20 Stat. L., 394).

Pursuant to the provisions of this law, the President appointed as Director of the Geological Survey, Clarence King, who, as already stated, had directed the geological exploration of the fortieth parallel. Mr. King organized a corps of geologists, most of whom had been connected with one or another of the former government surveys, among them being Major John W. Powell, who had conducted the exploration of the Colorado River and the geographical and geological survey of the Rocky Mountain region. This corps was organized by Mr. King in four sections, each to operate, under the direction of a chief, in a definite geographical district. For this purpose the territory west of the one hundred and second meridian was divided into four districts.

Extension of Operations to the Country at Large. As has been seen, the law of 1879 creating the Geological Survey authorized it to operate in the "national domain." This phrase was interpreted by Director King as referring only to "the region of the public land." At the same time, however, he urged upon the congressional committee the desirability of extending the operations of the Survey over the country as a whole. On June 28, 1879, the House of Representatives accordingly passed a joint resolution amending the act of March 3, 1879, by inserting after the words "national domain," the words, "and he may extend his examination into the states." In the Senate this joint resolution was reported back from committee with amendments authorizing such extension with the consent of the states, but it did not come to a vote.

The case for operations on a national scale was forcefully argued by the Director in his first annual report.⁶

⁶ P. 77 ff.

The great extent of the United States and the widely separated sources of the national resources render the acquisition by private citizens of information on almost any single product always difficult, often impossible.

As a direct result of the size of the country, the government and people have long been uninformed as to our primary industries; those, I mean, which yield the raw materials—mineral, vegetable, and animal.

To the Agricultural Department we owe the first reforms from this condition of wide-spread ignorance. In the realm of mineral productions the only efforts made to acquire any positive knowledge have been the highly useful, but feebly endowed, works of the late mining commissions, whose investigations were suffered to end for lack of appropriations.

Today no one knows, with the slightest approach to accuracy, the status of the mineral industry, either technically, as regards the progress and development making in methods, or statistically, as regards the sources, amounts, and valuations of the various productions.

Statesmen and economists, in whose hands rest the subjects of tariff and taxation, have no better sources of information than the guesses of newspapers and the scarcely less responsible estimates of officials who possess no adequate means of arriving at truth.

In no other intelligent nation is this so; on the contrary, mineral production is studied with the most elaborate effort. England, France, Germany, Austria, Russia, and Italy consider it essential to know, from year to year, not only the source and aggregates of amount and value of mineral yield, but many lesser facts relating to the modes and economies of the industries.

Upon considering the extent of country over which our minerals occur, their wonderful variety and yet unmeasured amounts, it cannot fail to be apparent that no private individual or power is competent to do what ought long since to have been done, namely, to sustain a thoroughly practical investigation and exposition of the mineral industry.

By way of example, and to show how hopeless it is to look to any other source than the government for this service, I select iron.

The lack of comprehensive knowledge of the occurrence and distribution of iron, despite numerous state and private investigations, is then set forth at length:

To claim that the iron question will ever be adequately investigated as a whole, either by private enterprise or State surveys, is to betray a total lack of appreciation of the character, magnitude, and needs of the industry.

What is true of this single metal is equally true of nearly the whole catalogue of the mineral products of the United States. A few exceptional items, like quicksilver, occur in such restricted areas that private or State enterprises could contribute all the knowable facts and features of the business of production. But as a whole it is true, and can never be refuted, that the Federal Government alone can successfully prosecute the noble work of investigating and making known the natural mineral wealth of the country, current modes of mining and metallurgy, and the industrial statistics of production.

Provided Congress extends the field of the Geological Survey over the whole national territory, and appropriates the comparatively small amounts necessary for the maintenance of the organization, it will be entirely practicable to carry forward this work, and contribute powerful aid to the mineral industries. Of the desirableness, from every point of view, of the results of a general geological survey, I conceive there cannot be two opinions. That these results can only be attained by an organization under Federal patronage, is, in my opinion, scientifically certain.

It was not until two years later that the recommendation of the Director was adopted by Congress and then only in part. The sundry civil appropriation act of 1882 (act of August 7, 1882, 22 Stat. L., 329) added to the original words of appropriation, which had been repeated in the act of 1880 and 1881, the words, "and to continue the preparation of a geologic map of the United States." It will be observed that the provision for "examination of the mineral resources and products" which had been made in the original act with respect to the national domain was not by this act extended to the country at large. It was not indeed until 1888 that all re-

strictions confining the work of the Survey to the public land region disappeared from the appropriation acts. In that year appropriation was made "for geologic surveys in various portions of the United States," a clause since repeated annually. Under this clause, which is much broader than the former clause authorizing the preparation of a geologic map, the Survey has extended every type of geologic investigation to the country at large.

As recently as 1914 the question was raised in Congress whether the work of the Survey should not be limited, either absolutely or conditionally, to the public lands, but no proposals embodying this view have ever received favorable consideration in either House.

In 1884 an agreement for coöperation was made between the Geological Survey and the Commonwealth of Massachusetts, which was about to undertake a topographic survey of the state, the expense of field work to be divided equally between the national survey and the state, the national survey to engrave the maps and give transfers of the plates to the state. This agreement, which worked out very satisfactorily, was but the first of a long series of agreements with the surveys of a number of the states for coöperation in topographic and subsequently in hydrographic and geologic work, and this form of state coöperation has been of the greatest value in permitting the extension of the Survey's standard methods and operations over the country at large much more rapidly than might otherwise have been possible. Coöperative agreements in geologic and paleontologic work were in effect with twenty-five states on June 30, 1917.⁷

As early as 1889 the Survey had informally extended its operations to the territory of Alaska, having sent its repre-

⁷ No attempt is made here to describe this system of coöperation in full, as the Survey has described it in detail in a pamphlet entitled "Coöperation between the United States and the Various States in Topographic, Hydrographic and Geologic Work, 1910." The extent to which states have coöperated up to June 30, 1917, is, however, shown in the report of the Director of the Survey for the fiscal year 1917, and is summarized in Appendix 5.

sentatives with various governmental and private exploring expeditions with a view to gathering geological data. It first became possible, however, to undertake comprehensive work in Alaska in 1895, when Congress appropriated \$5,000 for the investigation of the gold and coal resources of Alaska, and this amount was again appropriated in 1896 and 1897. Early in 1898, after rich gold deposits had been found in the Klondike region, in Canadian territory, the appropriation was increased to \$25,000. In 1901 the scope of the surveys in Alaska was extended to cover all mineral resources and the annual appropriation was increased to \$60,000. In 1905 it was increased to \$80,000, in 1909 to \$90,000, and in 1912 and later years to \$100,000. A total of over one and a half million dollars has thus been expended by the Survey on Alaskan surveys and investigations. Before the Survey entered Alaska only the most meager information was available not only as to its resources but even as to the major features of its geography. In thirty years the Survey has mapped topographically over one-third of its surface and has made geologic explorations, in greater or less detail, over almost the whole of this part of its area.

Even prior to their acquisition by the United States, the Survey had from time to time made geologic researches in Hawaii, Cuba and Porto Rico. In 1899 Congress by resolution called upon the Survey for information as to existing surveys of our insular possessions, and for estimates of the cost of further surveys. No action was taken by Congress on the report presented, however, nor has any express authority ever been granted to the Survey to extend its operations to those possessions. In 1910, however, the Survey entered into a co-operative agreement with the territorial government of Hawaii for the topographic survey of the territory which had already been begun by the territorial government, and work under similar agreements has since been steadily prosecuted. Similarly, in 1912, an agreement was entered into by the Survey

with the Isthmian Canal Commission and the Smithsonian Institution for geologic studies in the Canal Zone.

Development of Survey's Functions. The broad purposes of the Survey's work have remained constant throughout its history, but its functions and the manner of their performance have undergone many changes from time to time. These will here be briefly outlined, detailed discussion of the development of particular activities being reserved for the following chapter.

The organic act of 1879, together with the amending act of 1882, specified four distinct functions to be performed by the Survey—the geological survey of the public lands, the classification of the public lands, the examination of the geological structure and the mineral resources and products of the national domain, and the preparation of the geologic map of the United States.

At first the Survey took the position that by the term "classification of the public lands," Congress did not intend to imply a detailed survey of the individual tracts of land in the public domain, with respect to their inclusion under the provisions of one or another of the public land laws, but merely a general survey of the soil and mineral characteristics of the lands. In effect, therefore, this portion of the law was regarded as adding little if anything to the clauses calling for the geological survey of the public lands and for the examination of the mineral resources and products of the national domain, and in this interpretation Congress apparently acquiesced, as it was followed by the Survey for many years without evoking any change in the phraseology of the successive appropriation acts.

The authority to prepare a geologic map of the country was construed by the Survey as giving authority to prepare also a topographic map; the position being taken that a geologic map could properly be prepared only if a topographic map were available as a base.

In accordance with the interpretation of the statutes the early

work of the Survey fell into three classes: (1) topographic surveys; (2) geologic surveys in areas of economic importance or theoretical interest; (3) research in geologic theory and the theory of related sciences.

In 1882 the scope of the Survey's functions was enlarged by a provision in the appropriation act for the year 1882-3 that "not to exceed ten thousand dollars of the amount appropriated may be applied under the direction of the Secretary of the Interior to the procuring of statistics in relation to mines and mining other than gold and silver and in making chemical analysis of iron, coal and oil." Almost immediately upon its organization the Survey had undertaken to collect statistics of mines and mining in coöperation with the Tenth Census. The legislation quoted placed the work upon a permanent basis and permitted the publication by the Survey in 1883 of a volume entitled "Mineral Resources of the United States," comprising over 800 pages of statistical matter for the calendar year 1882. An appropriation for the preparation of this report has since been granted every year, and the report has come to be one of the best known of the Survey's publications.

Congressional Investigation of 1886. The Survey had been in existence but little over five years when its plans and methods became the subject of a sweeping inquiry by a joint congressional commission. The rapidly growing appropriations for several large scientific bureaus of the government—the Geological Survey, the Signal Service (which then performed the functions since vested in the Weather Bureau), and the Hydrographic Office—became, beginning in 1883, a subject of discussion in Congress, and in 1884 provision was made in the sundry civil appropriation act (23 Stat. L., 219) for a joint congressional commission to "consider the present organizations" of the bureaus mentioned, "with the view to secure greater efficiency and economy in the administration of the public service in said Bureaus." The commission appointed held numerous hearings in 1885 and 1886, Major

Powell, the Director, appearing for the Survey.⁸ The main questions regarding the Survey's work raised in hearings related to the value of topographic maps executed on so small a scale as was then employed by the Survey, the rate of progress toward completion and publication of the Survey's geological maps, and the propriety of the wide scope of the Survey's scientific investigations and publications.

While the minority of the commission, consisting of two of the six members, submitted a report criticizing the Survey on the score of costliness, slowness and lack of practical applicability of its work, the majority expressed the opinion that the Survey as a whole was "well conducted, and with economy and care, and discloses excellent administrative and business ability on the part of its chief."⁹ They reported, however, in favor of restricting the printing or engraving of "the scientific reports known as Monographs and Bulletins of the Geological Survey" by requiring that specific and detailed estimates should be made therefor and specific appropriations made in pursuance of such estimates. This provision was accordingly incorporated in the sundry civil appropriation act adopted shortly afterward (act of August 4, 1886, 24 Stat. L., 255).

In 1888 the appropriation for the operating expenses of the Survey, which had up that time been granted as a lump sum, was itemized under eight heads; and of a total appropriation of slightly over \$737,240, \$40,000 was appropriated for "paleontologic researches" and \$17,000 for "chemical and physical researches." Thus, within two years after the commission had made its report, Congress by express action sustained the Survey in its paleontologic and chemical and physical research, the utility of which had been questioned by

⁸ Major Powell's testimony furnishes a mine of information relative to the early operations of the Survey. All the testimony taken by the commission was printed as Senate Misc. Doc. No. 82, 49th Congress, 1st Session (Vol. 4 of Misc. Docs.).

⁹ Senate Report No. 1285, 49th Congress, 1st Session.

the minority of the commission, and these provisions became permanent features of the appropriation acts of the Survey.

The Powell Irrigation Survey, 1888-1890. The Director of the Survey, Major Powell, had for some years been deeply interested in the question of reclamation of the arid public lands by irrigation. In 1878 he had rendered to the Commissioner of the General Land Office a "report on the land of the arid region of the United States with a more detailed account of the land of Utah." In discussing the methods to be employed for the reclamation of the arid lands, he had stated that it involved engineering problems requiring for their solution the greatest skill, as well as the employment of large capital and possibly government aid, if not direct government construction. By 1888 the continued appropriation and reduction to private ownership of the readily available streams in the arid region, which he had foreseen, resulted in the authorization by Congress of investigation by the Geological Survey of "that portion of the arid regions of the United States where agriculture is carried on by means of irrigation, as to the natural advantages for the storage of water for irrigation purposes, with the practicability of constructing reservoirs, together with the capacity of the streams and the cost of construction and capacity of reservoirs, and such other facts as bear on the question of storage of water for irrigating purposes." By an appropriation act passed a few months subsequently and by one passed in 1889, a total of \$350,000 was appropriated for the conduct of this investigation.

The act of October 2, 1888 (25 Stat. L., 526), however, in addition to making appropriation for the investigation, directed the Survey to designate all lands which might be used "for sites for reservoirs, ditches, or canals for irrigation purposes, and all the lands made susceptible of irrigation by such reservoirs, ditches, or canals;" and it was provided that all such lands "are from this time henceforth hereby reserved from sale as the property of the United States, and shall not be subject after the passage of this act to entry, settlement or

occupation until further provided by law." Thus, for the first time, the Survey was vested with powers of direct administration with respect to the public domain.

Immediately upon the enactment of this legislation, the Survey organized a large force, composed principally of topographic engineers, and undertook a vigorous prosecution of the project entrusted to it. Within a little more than a year after its organization this branch of the Survey, which is commonly referred to as the Powell Irrigation Survey, segregated 127 reservoir sites, having an area of over 2,500 square miles, and, in addition, over 30,000,000 acres of irrigable land located in five distinct basins.¹⁰

The sweeping action of the Survey provoked a wide-spread protest from persons in the arid region who were adversely affected and as a result a special committee of the Senate was appointed to investigate the entire subject. The report of the majority of the committee, rendered in 1890, severely criticized the policy adopted by the Survey.¹¹ By the act of August 30, 1890 (26 Stat. L., 391), the whole of the act of 1888 was accordingly repealed except as to reservoir sites, the segregation and reservation of which was expressly continued. The appropriations made in 1888 and 1889 for the survey of the arid lands were also discontinued.

Though it may be said that the operations of the Powell Irrigation Survey thus met with congressional disapproval, the actual results achieved by it in topographic maps of the arid regions and in stream measurements constituted a work of enduring value and furnished the basis upon which the subsequent work of the Survey in connection with reclamation was largely based.

Whether because of the disfavor with which its operations

¹⁰ The reports on the operations of the Powell Irrigation Survey were published in separate volumes of the annual report of the Director of the Survey for the fiscal years 1889 to 1892, inclusive. The figures are taken from the volume for 1889, page viii.

¹¹ The report of the committee together with the record of the hearings held by it was printed as Senate Report No. 928, 51st Congress, 1st Session.

in the arid lands had been viewed by Congress or because of the general tendency to reduce appropriations as a result of the economic depression in the country, the appropriations to the Survey suffered a heavy reduction in the period from 1890 to 1896. Up to and including the fiscal year ending June 30, 1890, the Survey's appropriations had increased with every year, the increase being in one year as high as \$150,000, so that for the fiscal year 1890 the total amount appropriated was over \$875,000. For the fiscal year 1891 the appropriation was reduced to less than \$850,000, but the reduction was due entirely to the elimination of the irrigation survey, the appropriations for topographic and geologic surveys receiving a marked increase. In the following year the appropriation for topographic surveys was somewhat reduced, so that the total appropriations were but little more than \$700,000. During the next three years, however, the reductions were exceedingly heavy, the amount for topographic surveys being reduced successively from \$250,000 to \$240,000, \$200,000 and \$150,000; but the appropriation for geologic surveys, at first reduced from \$115,000 to \$50,000, was subsequently increased to \$70,000 and \$100,000. Proportionately, the heaviest reductions were made in the relatively small appropriations for paleontological researches and chemical and physical researches, the former being reduced from \$40,000 in 1892 to \$10,000 for the three following years, and the latter from \$17,000 in 1892 to \$5,000 in 1893 and 1894, and \$7,000 in 1895. In 1895, accordingly, the total appropriation for the Survey was but slightly over \$500,000; less than had been appropriated for the year 1886. With the fiscal year 1896 a period of substantial increase again set in which has continued without material interruption until the present time.¹²

The figures presented show that in the early nineties the topographic work of the Survey had become perhaps its major activity as determined by percentage of cost. The grow-

¹² All the appropriations for the Survey are shown in detail in tabular form in Appendix 5.

ing importance of this work was further emphasized by the third director of the Survey, Charles D. Walcott, who succeeded Major Powell in 1894. Mr. Walcott, in his first annual report, announced his intention of enhancing the value of the topographic survey for other than geologic purposes and ordered the representation upon the topographic maps of land subdivision lines and township and section corners in the public land states, and he obtained authority from Congress to print and sell the topographic maps with text for educational purposes.

The desirability of having detailed topographic maps of an area in advance of its geologic or other special investigation resulted, very early in the Survey's history, in the extension of topographic work over large areas that had not been covered by geologic investigations. So extensive and accurate was the topographic work thus performed that it rapidly assumed an importance of its own quite independent of its prospective utilization in connection with the Survey's geologic or other work. In 1888 this condition was recognized by Congress by a specific appropriation for the first time for topographic work, and in the next year by the transfer to the Geological Survey of the work of engraving the topographic and geologic maps—work that had formerly been entrusted to private engravers, under contract with the Government Printing Office.

In 1896, by a special act of Congress, a new function was temporarily imposed upon the Survey, that of conducting a land subdivision survey. The work was done in the Indian Territory during the years 1896 to 1898. The Director of the Survey reported that this work had demonstrated "that it is more economical to survey large areas in this manner than under the contract system heretofore employed by the Government in its land subdivision surveys. This statement applies to large areas embracing one thousand square miles or more." With respect to smaller areas the Director was of the opinion that the system of employing local surveyors under contract was the more economical. No subsequent land sub-

division surveys have been required of the Survey by Congress. In 1898 there was, however, an appropriation made for the survey by the Geological Survey of the northern portion of the Idaho-Montana boundary, and from time to time other boundary surveys have been made by the Survey.

The history of the Survey's geologic and topographic work in the next decade is one of steady progress along established lines, and a rapid development of that part of its work which had direct economic application. The extension of its operations to Alaska, beginning in 1895, has already been mentioned. During these years, in addition to thus entering a field where rapid economic development was imminent, the Survey attacked in succession three major problems of the conservation of the natural resources of the country—the conservation of the national forest lands, the reclamation of the arid public lands, and the elimination of waste, both of raw material and of life, in the mining industries of the country.

Survey of Forest Reserves. From its beginning, in connection with its regular geologic and topographic surveys, the Survey had gathered data relative to the country's forests; and in 1891, on the enactment of a law authorizing the President to set aside forest reserves on the public lands, the Survey had been able to give advice to the Secretary of the Interior as to the determination of the boundaries of such reserves. The lack of definite information as to the conditions and resources of the lands included in the forest reserves had made impracticable, however, any attempt to administer them. In 1897, therefore, Congress appropriated \$150,000 "for the survey of the public lands that have been or may hereafter be designated as forest reserves by Executive proclamation," specifying at the same time that these surveys should be made under the supervision of the Director of the Survey (30 Stat. L., 34). Under this authority the Survey began a thorough survey of the national forests—their distribution, the size and density of the timber, the distribution of the leading economic species, the damage inflicted by fires, the amount of dead tim-

ber, the extent to which the forests are pastured, the amount of timber already cut and the effects of deforesting, the relations of timber supply and transportation, the local demands of miners and settlers, and the supply needed for more distant markets. Upon the basis of the information thus gathered, regulations for the use of the forest reserves were framed and the boundaries of the reserves were readjusted.

The examinations of the forest reserves were carried steadily forward for seven or eight years and covered about 75,000,000 acres. In addition to reports on the several reserves, the Survey undertook, in connection with these examinations, the preparation of land classification maps of the areas examined. These maps were prepared on the regular atlas sheets of the Survey as bases, and showed not only the forests with burnt and cut lands but the irrigable and pasture lands. In all some forty sheets of this type were prepared and published.

During the years 1897 to 1905 the data collected by the Survey relative to the forest reserves furnished the basis of the regulations governing those reserves and of the administration of those regulations. The actual administration of the reserves was, however, vested in the General Land Office. In 1905 the administration was transferred to the Bureau of Forestry of the Department of Agriculture, which was renamed the Forest Service. To this Service was also transferred all further examination and classification of the forests; and the work of the Survey relating to forests was henceforth limited to "topographic surveys on public lands which have been or may hereafter be designated as national forests," an activity for which specific appropriations, varying in amount from \$100,000 to \$75,000, have since annually been made.

Stream Gaging and Reclamation Work. After the repeal, in 1890, of those parts of the act of 1888 that provided for the segregation of sites for canals and ditches and of lands made available for irrigation, the appropriations made to the Sur-

vey during 1888 and 1889 for surveys in the arid lands had also been discontinued. In 1894 the Survey, however, obtained a specific appropriation of \$12,500 "for gauging the streams and determining the water supply of the United States, including the investigations of underground currents and artesian wells in arid and semiarid sections." This small appropriation was doubled for the fiscal year 1896 and that amount again doubled for the fiscal year 1897, so that for the three years 1897 to 1899 it stood at \$50,000, rising to \$70,000 in 1900 and \$100,000 in 1901, the terms of the appropriation being broadened, however, in 1896 to read: " * * * for gauging streams and determining the water supply of the United States, the investigation of underground currents and artesian wells and the preparation of reports upon the best methods of utilizing the water resources." As a result of the operations conducted under these appropriations, which, though they extended over the whole country, were naturally concentrated in the arid regions, the Survey accumulated a most extensive body of information regarding the water resources of the arid regions, particularly with reference to their availability for irrigation. It was but natural, therefore, that upon the passage, in 1902, of the reclamation act, the administration of the act should be entrusted by the Secretary of the Interior to the Survey.

The Reclamation Service was first organized merely as a division of the so-called Hydrographic Branch, the chief of that branch acting also as chief engineer of the Reclamation Service. As the work of that service passed, however, from the stage of planning to that of actual construction, its association with the Hydrographic Branch and then with the Survey itself became more and more nominal until, in 1907, pursuant to a recommendation made by the Director of the Survey, it became an independent service, subject to control only by the Secretary of the Interior, its chief engineer, the former chief of the Hydrographic Branch of the Survey, becoming its director. Since that time the relation between the Survey

and the Reclamation Service has been merely that of coöperation in respect to certain matters of stream measurement.

Work in Mining Technology. From the first the Survey had established a close relation to the mining and mineral industries of the country through the preparation of its annual report on "Mineral Resources of the United States." This relation was steadily strengthened by investigations made by the Survey in important mining areas, by investigations and publications relative to technologic processes, and by the publication, beginning in 1894, of parts of a geologic map of the country, of which the early issues covered, almost without exception, areas of interest to the mining industry. In 1898 the growth of this relation of the Survey to the mining industry was reflected in the introduction into Congress of a resolution¹³ calling for the creation, by statute, in the Survey, of a separate division of mines and mining, with a specific appropriation, on the ground that the mining interests of the country should have "a clearly defined representation in the organization of the Government." Its passage was recommended by the Survey, but without success.

Some six years later Congress authorized the Survey to undertake a kind of work which had been mentioned by the Director, in his report recommending the establishment of a division of mines and mining,¹⁴ as one which might well be taken up by such a division—a systematic inquiry into the values of the several deposits of economic minerals in the country. By act of February 18, 1904, there was appropriated the sum of \$30,000 "for analyzing and testing the coals and lignites of the United States." In 1905 this appropriation was enlarged to \$227,000 and was extended to cover all fuels; and simultaneously there was added an appropriation for investigating structural materials. In the next few years the appropriations for both these purposes were largely increased.

In connection with both investigations, as they proceeded,

¹³ Senate Res. No. 205, 55th Congress, 3d Session.

¹⁴ Annual Report for 1898-1899, p. 21.

the Survey was called upon to give expert advice to other branches of the government as to the fuels and structural materials used by them; and the preparation of specifications and the testing of fuels and materials came to be a standing feature of the Survey's work.

The emphasis which had thus tended, in this field of the Survey's work, toward the technologic rather than the geologic aspect of the mineral industries was strengthened by an appropriation made in 1908 (act of May 22, 1908) "for the protection of lives of miners in the territories and in the districts of Alaska, and for conducting investigations as to the causes of mine explosions with a view to increasing safety in mining." Under this appropriation the Survey made examinations of explosives used in coal mining in the United States, of the occurrence of explosive gases and inflammable or explosive dust, of safety lamps and mine-rescue apparatus, and of the use of electricity in mines. These investigations, like the forestry surveys, necessitated the addition to the Survey's personnel of an entirely new staff of technical experts—mining technologists.

For the fiscal year 1908-09 the appropriations for the three classes of technologic investigations just described—testing of fuels, testing of structural materials, and investigation of mine explosives—had reached a total of over \$500,000, and though in the next fiscal year the item for testing fuels was reduced from \$250,000 to \$100,000, it was evident that the investigations of mining accidents would continue to grow in cost and importance. The lack of intimate connection between these investigations and the regular geologic work of the Survey, and the feeling, which, as already seen, had been expressed in Congress more than ten years before, that the mining industries of the country should have definite representation in the government, resulted in a proposal that a Bureau of Mines be created as an independent bureau of the Department of the Interior, and that it take over and develop the work in mining technology begun by the Survey. By act of May 16, 1910,

this proposal was enacted into law, and on July 1 the personnel of the Technologic Branch of the Survey was organized as the Bureau of Mines, the chief of that branch becoming the first director of the new bureau.

By the same act, the investigation of structural materials was transferred to the Bureau of Standards.

Land Classification Work. The three important phases of the Survey's work just traced—in forestry, reclamation, and mining technology—had all been undertaken in pursuance of special statutory authority. About 1905, however, an activity of prime importance was begun without any change in the law.

The very first clause in the definition of functions in the act of 1879 creating the Survey had provided that the Survey should have charge of "the classification of the public lands." This phrase, however, was from the first interpreted by the Survey, and inferentially also by Congress, as calling for a mere geologic and mineralogic examination of the public lands without reference to the public land laws. For over twenty years this interpretation governed, but then the General Land Office and the Secretary of the Interior began to call more frequently upon the Survey for its opinion, based on information either already gathered by it or obtained by special investigation, as to the applicability of particular provisions of the land laws to specific tracts of public land to which patent was sought by private parties or with respect to which official action was contemplated. In 1906 the Survey undertook, with the approval of the Secretary of the Interior, a systematic valuation of the public lands that were believed to contain coal, in order to determine the prices at which such lands should be sold by the government under the coal land law. This work is still in progress and to it has been added the examination and classification of oil, phosphate, potash, and mineral lands, and of lands suitable for water-power sites, as well as enlarged homesteads and stock-raising homesteads. Today the classi-

fication of the public lands by the Survey constitutes an integral part of their administration.

In the last decade the functions of the Survey have not materially changed. Rather there has been a marked development of the existing functions of the Survey in the direction of increasing the popularity and practical value of the results of its work. This tendency is seen particularly in the more popular character of some of the publications, in the more prompt publication of statistics of mineral resources, and in the vigorous prosecution of geologic and mineralogic inquiries having for their purpose the location of deposits of phosphates, nitrates, petroleum, potash, and other minerals for which there is an urgent industrial need.

The Survey and the War. Many of the early surveys of the West were largely military. Among their objects was the ascertainment of the most practicable routes of transportation in a country not supplied with railroads, the topography of the country as bearing on the conduct of military operations, and the resources and development of the country with respect to its ability to furnish supplies for troops. As the West developed and as the Geological Survey extended its topographic mapping over larger and larger areas of the country, the need for separate military surveys largely disappeared and the maintenance of a corps of topographical engineers by the Army was discontinued.

In 1916 the War Department received an appropriation of \$35,000 for the conduct of certain topographical surveys deemed necessary in connection with the development of plans for the national defense. An agreement was entered into between the War Department and the Survey by which the appropriation was expended by the Survey under the direction of the War Department. In the execution of this work the Survey prepared a specimen topographical map similar to that developed by the best European practice in military mapping.

In March, 1917, the recognition of the urgent needs of the

military service resulted in the plans for the Survey's entire field work in topography being made to conform to a program drawn up by the General Staff of the Army. The map printing plant of the Survey was also made available to the War and Navy Departments for which it has printed a great number of charts and maps.

In addition to these military topographic surveys, the Survey made special examinations of underground waters and soil drainage in a number of localities that were under consideration by the War Department for military encampments.

Of no less importance for the prosecution of the war are the special investigations which have been made by the Survey with a view to locating new deposits of minerals, both metals and non-metals, required in the manufacture of munitions. Among these minerals are manganese, pyrite, platinum, chromite, tungsten, antimony, potash, quicksilver, and nitrate.

Perhaps the most striking contribution made by the Survey to the military service has been the group of specially trained engineers in its personnel who have been commissioned in the Engineer Officers' Reserve Corps. At the end of the fiscal year 1917, this group included one geologist, seven hydrographic engineers, and sixty-one topographic engineers.

CHAPTER II

ACTIVITIES

In the preceding chapter the development of the activities of the Survey has been briefly outlined. In the present chapter each of these activities will be treated in turn and the attempt will be made to trace in some detail its origin and development, its present purpose, the method of its performance and the progress made to date in accomplishing the program proposed.

It may be said that all the activities of the Survey have, broadly speaking, two purposes—that of making public information regarding the topography and resources of the country, and that of obtaining information necessary for the proper administration of the laws governing the disposition of the public lands.

As indicated in the preceding chapter, though the general character of the Survey's activities is determined by the permanent provisions of laws establishing and governing the Survey, which provide that the Director of the Survey shall have charge of "the geological survey and the classification of the public lands and examination of the geological structure, mineral resources and products of the national domain, . . . shall continue the preparation of a geologic map of the United States," yet the extent and the specific nature of the work may be determined by the annual appropriations made for the Survey's work. The appropriation acts for the year ending June 30, 1918, specifically authorize expenditures for the following activities:

1. Topographic surveys in various portions of the United States.

2. Geologic surveys in various portions of the United States.

3. Chemical and physical researches relating to the geology of the United States, including researches with a view of determining geological conditions favorable to the presence of deposits of potash salts.

4. Investigation of the mineral resources of Alaska.

5. Preparation of a report on the mineral resources of the United States.

6. Gaging streams and determining the water supply of the United States, the investigation of underground currents and artesian wells, and the preparation of reports on the best methods of utilizing the water resources.

7. Discovering, developing, protecting and rendering more accessible springs, streams and water holes on arid public lands of the United States; erecting and maintaining monuments and sign boards and providing ready and convenient means by which water may be brought to the earth's surface.

8. Examination and classification of lands requisite to and suitable for enlarged homesteads, stock-raising homesteads, public watering places and stock driveways as required by the public land laws.

The scope of the activities thus authorized is of course dependent upon the amount of the appropriation. As will hereafter be noted, the act further controls the scope of some specific activities by a special provision regarding the manner of the utilization of the amount appropriated.

For a clearer presentation the activities of the Survey may be regarded as falling under the following seven heads:

1. Geologic surveys and investigations.
2. Compilation of information relative to the mineral industries.
3. Topographic surveys.

4. Surveys and investigations relative to water resources.
5. Examinations, under act of March 1, 1911, of land proposed to be purchased by the government for the protection of navigable streams.
6. Investigations of the character and value of public lands made necessary by the land laws.
7. Operation of lithographing and engraving plant.

As the purpose of the larger part of the Survey's work is the acquisition and dissemination of knowledge concerning geography, geology, mineral resources, and water resources, most of its activities, therefore, involve the publication of the results achieved.

Topographic Survey. As already indicated, the Survey is engaged in making and publishing a topographic atlas of the United States—that is, a series of maps exhibiting the configuration of the land and water, the elevations of the land, and the principal features of culture. In addition to these atlas sheets it is publishing special maps of certain areas—such as the areas including large cities.

The work on the topographic atlas was begun by the Survey in 1882, promptly upon the enactment of the provision of law authorizing the Survey to prepare geologic maps of the United States. In entering upon the task, one of unprecedented magnitude, of executing a topographic survey of the entire United States, the Survey fell heir to the results which had been produced by previous topographic surveys, federal, state and private. Notable among these results were the maps produced by the several geographical and geological explorations and surveys of the West, to which reference was made in the preceding chapter. The materials thus acquired were of very unequal value, but they furnished a point of departure for the Survey's work.

The Survey did not for some years attempt to publish topo-

graphic maps for general distribution, but supplied them only to its own members and to other government services. Authority to sell the maps to the general public was finally granted by Congress in 1897 (act of February 18, 1897, 29 Stat. L., 701).

During the first few years of the Survey's map work it continued to use the same scale that had been employed by the earlier independent surveys—about 4 miles to the inch, or 1:250,000, with relief shown by 200-foot contours; but when the coöperative surveys of the states were begun it was seen to be desirable to increase the scale and decrease the contour interval, not only for the work in those states, but for that in other states in which coöperation was not being carried on.

The earlier topographic mapping of the Survey was subjected to some criticism on account of lack of refinement in detail. It was a question of judgment whether the appropriation should be expended in accurately mapping a limited area or in making reconnaissance surveys over a more extended area. The less accurate maps were less expensive, and served a useful purpose in establishing the value of topographic surveys. The results have proved the wisdom of a policy whereby the people were gradually educated to the use of refined and detailed maps, while Congress learned to appreciate the cost and the comparative slowness with which accurate surveys would be prosecuted over so vast a territory as that of the United States. Had fewer square miles been mapped annually in the early years, but with the accuracy attained at present, it is doubtful if Congress would have continued to maintain the organization. As it was, valuable results were rapidly put forth, and in time it has been possible to supersede the older reconnaissance maps with more detailed maps.¹

As the topographic work steadily advanced, not only in the area covered, but in accuracy, it was found desirable to obtain from Congress authority to run careful spirit-level lines and to establish bench marks for permanent record of eleva-

¹ U. S. Geological Survey, Bulletin No. 227, 1904, p. 57.

tions upon the ground, and also to carry on control by triangulation or traverse with greater accuracy and to mark the positions more permanently than had been possible without statutory authority. Accordingly, on June 11, 1896, an act was approved which provided that "elevations above a base level located in each area under survey shall be determined and marked on the ground by iron or stone posts or bench marks," etc. Thereafter it was possible to provide for the running of careful spirit levels over all the areas under survey and to extend the amount of spirit leveling, thereby securing more accurate location of contours. Since that act was passed the topographic mapping has reached as high a degree of detail and quality as seems desirable for the scales adopted.

The selection of areas for survey is determined by a variety of considerations. It is of course desired to extend the benefits of the work as widely and equally over the country as a whole as is economically practicable. Other things being equal, however, it is more economical to extend surveys outward continuously from areas already surveyed than to undertake new work in areas entirely unconnected with them by triangulation or otherwise. A special economic need or project in an isolated area may nevertheless occasionally warrant the initiation of a survey there. As between areas equally economical of survey, preference is determined by a number of factors, among which are the apparent local demand for surveys, and the probable economic value of the resultant maps.

The methods of field work followed by the Survey in making topographic surveys are unique and have been developed by the topographers of the Survey through nearly forty years of field experience. "Wherever possible the results of triangulation by other organizations are utilized. The degree of refinement in the detailed surveying depends upon the scale upon which the resulting map is to be drawn.

The results of the topographical surveys are published in the form of Topographic Atlas Sheets, measuring 17 by 20 inches. These sheets are published on different scales, the

scale selected varying with the character of the area mapped and the degree of detail required. These scales are 1:62,500, 1:125,000, and 1:250,000; that is, approximately 1 mile, 2 miles, and 4 miles to the inch, respectively. A sheet thus represents an area of approximately 230 square miles, 920 square miles, or 3,700 square miles. The largest scale, showing the most detail and representing the smallest area, is used for densely populated or otherwise important areas; the next largest for sparsely inhabited mountain regions; the smallest for areas covered by reconnaissance or exploratory surveys, especially in the western states and Alaska.

The boundaries of each quadrangle, as the area mapped on a single sheet is known, are meridians of longitude and parallels of latitude, the differences in longitude or latitude between the boundaries being in the largest scale maps 15', and in the smaller scales, 30' and 1", respectively.

The maps show the topographic features of the land, such as mountains, hills, valleys, and gulches; all bodies of water, such as lakes, marshes, streams, and springs; the routes of travel, such as railroads, wagon roads, and trails; political boundaries; cities, towns, and permanent buildings; and the names of natural and other features. They also indicate exactly the location of permanent survey monuments and bench marks whose positions and whose elevations above sea level have been determined by precise methods. The maps of areas covered by public land surveys show all township and section lines as well as the boundaries of all land grants.

Each of these maps is printed in three colors—black for the cultural features, such as boundary lines, roads, railroads, houses, towns, and cities, and for the names of all things represented; brown for the relief, or the element of elevation, indicated by contour lines showing the heights of all parts of the area above sea level; and blue for the water—the rivers, lakes, and the sea and its bays and inlets.

Each sheet is named from some prominent natural or other feature within the quadrangle it represents, such as a lake,

mountain, town or city. Index maps showing the location and names of quadrangles mapped in any state or region are published.

In addition to regular topographic atlas sheets many special topographic maps have been published of areas having particular interest, such as large cities and their environs, or regions embracing natural wonders. The Survey has also been engaged for some time in participating in the preparation of the United States portion of the millionth scale map of the world—that is, a map having a scale of one to one million, or a scale of about sixteen miles to the inch. This map is to be part of an international map of the world upon a uniform scale. A few sheets of this map have already been published by the Survey. A number of base maps of the several states and of the United States are also published by the Survey.

Historically considered, the topographic maps produced by the Survey are primarily of use to the Survey itself as necessary bases for geologic maps, but they are now to be regarded as the basic and standard topographic maps of the country for all purposes. They are used by virtually all departments of the national, state, and local governments in the location of field offices, the determination of the boundaries of administrative districts and the consideration of projects for public works, a use in which they are of special value. Before these maps were made, for example, every city was obliged to spend large sums in surveys for water supply. These topographic maps now furnish all necessary data for a far larger area than would be embraced in a local survey. In engineering works, whether municipal or constructed by private capital, and in industrial, mining, and agricultural operations of every sort, the Survey's topographic maps are also of the highest value. The maps are widely used, moreover, in traveling and in countless other activities of every-day life. The extent of their use is indicated by the annual sales, which now amount to over half a million copies.

Attention should be called to the especial value which at-

taches to the Survey's topographic maps of Alaska, because of the undeveloped state of the country. Demands for them come from prospectors, engineers, capitalists, and school teachers, and they form one of the most essential preliminaries to any form of development of the country. They indicate routes of travel to the prospector and explorer, railway and wagon routes to the locating engineer, and possible sources of water power to the mine operator.

Cost and Progress. The cost of the surveys first made, on the scale of 4 miles to the inch, averaged \$1.75 a square mile. Those made later, on the scale of about 2 miles to the inch, averaged in cost \$4 a square mile, and those made on the scale of approximately 1 mile to the inch, averaged in cost \$10 a square mile. During the field season of 1884 a single party mapped over 11,000 square miles on the scale of 4 miles to the inch. A few years later the output of a single party, on the scale of 2 miles to the inch, was about 3,000 square miles in a season. Today the more refined and detailed maps, on the scale of about 2 miles to the inch, with a contour interval of 100 feet, cost from \$7 to \$11 a square mile, according to the country, and a single party can rarely map over 600 to 1,000 square miles in a season. On the scale of 1 mile to the inch, a party rarely maps more than 500 square miles in a season, and the cost of this work varies between \$12 and \$30 a square mile, according to the nature of the country.

It would be difficult to compute with accuracy the total cost of the topographic surveys and of the topographic maps to date. As already stated, the Survey inherited from the several western surveys which preceded it a large body of material which it was able to utilize in the preparation of its early topographic maps. Again, it was not until eight years after the Survey began topographic surveys that specific appropriation was made for them by Congress. The state contributions to topographic work, amounting to nearly two and one-half million dollars, must also be taken into account. The total specific appropriations for topographic surveys to date have been

over eight million dollars. Thus, it seems safe to say that the total cost of these surveys and of the preparation of the topographic maps has been not less than twelve million dollars.

Of the 3,026,789 square miles in the United States proper, 1,257,623 square miles have now been mapped, covering about 2,225 sheets. The accompanying map, taken from the annual report of the Director of the Survey for 1917, shows the progress that had been made up to June 30 of that year in the execution of the topographic survey of the country.

In addition, there have been mapped 202,361 square miles in Alaska, comprising over 34 per cent. of the total area; and 1,393 square miles in Hawaii, comprising 22 per cent. of the total area.

Erection of Bench Marks. In connection with its topographic work, the Survey erects bench marks in areas surveyed, a bench mark being a monument upon which is noted its elevation. This work has been carried on since 1896, in pursuance of an act of Congress passed in that year which required that thereafter in topographic surveys "west of the ninety-fifth meridian, elevations above a base-level located in each area under survey shall be determined and marked on the ground by iron or stone posts or permanent bench marks, at least two such posts or bench marks to be established in each township or equivalent area, except in the forest-clad and mountain areas, where at least one shall be established, and these shall be placed, whenever practicable, near the township corners of the public land surveys; and in the areas east of the ninety-fifth meridian at least one such post or bench mark shall be similarly established in each area equivalent to the area of a township of the public land survey."

A bench mark serves two purposes—that ordinarily served by a monument of establishing an exact point of reference in the use of the topographic maps (the location of the bench mark being indicated on the map), and that of furnishing for all purposes a permanent record on the land itself of its eleva-

tion. Bench marks also are of value in the progress of the Survey's topographic work as fixed points of reference for the extension of its level lines.

It will be noted that the act of 1896 does not require that the elevations of the bench marks above sea level be determined, but only "the elevations above a base level located in each area." Any attempt to determine elevations above sea level in the initial survey of an area might have necessitated the running of thousands of miles of precise levels in order to connect with sea level the initial points within each of the areas under topographic survey. This would have cost immense sums and would have occupied several years, during which the topographic surveys would have had to be continued without spirit leveling. The Survey, therefore, designated some point within each area under topographic survey as a central datum point for that area, and determined the elevation of that point as nearly as practicable from existing elevations adjusted by railway levels or other levels brought from the sea. In consequence, though all the elevations referred to the same central datum point agree one with the other, they may not be reduced to mean sea level because of the differences between the primary elevations on which the leveling is based. However, prior to and since 1896 precise-level lines have been extended by the Survey and other organizations to more accurately determine inland elevations above sea level, and the elevations originally determined have been corrected from time to time, so that at present nearly all the central points have been reduced to mean sea-level datum and carry with them all the levels resting thereon. As the area referred to a single base is gradually widened, it becomes possible to correct the elevations with reference to a new base, the corrections being, if practicable, entered upon the bench mark.

The location and elevations of the bench marks are published in two ways—first, by a symbol on the atlas sheets, accompanied by the letters "B.M." and the elevation to the near-

est foot; second, by lists of bench marks in the annual reports or bulletins of the Survey, with a full description of each bench mark and its exact elevation above sea level to the thousandth of a foot, as adjusted and referred to the various central datum points, these lists being corrected in publications from time to time as better connections are made with sea level. These publications are issued separately for each state.

Geological Survey. As perhaps its basic activity, the Survey is carrying on a survey of the areal geology and geological structure of the United States. By means of this survey it seeks to ascertain the distribution, structural relations, mineralogic character, economic value, and geologic history of the formations of each area surveyed. The results of this survey it publishes in the form of maps, illustrations, and textual descriptions.

The selection of areas for geologic survey is determined by a variety of considerations, corresponding closely to those mentioned in connection with the distribution of the topographic surveys. Still another element is the desirability of giving preference to the public land areas because of the value of geologic mapping in furnishing information needed by the General Land Office in the administration of the land laws.

The degree of refinement of the geologic survey varies with the character of the area and the results desired. The scale of the map on which the results are to be published is determined by the same considerations as in the case of topographic mapping. The three scales used in the topographic mapping—1:250,000, 1:125,000 and 1:62,500—are used also in the geologic mapping and according as one or the other map scale is contemplated the survey is said to be exploratory, reconnaissance, or detailed. Larger scales also are used.

The geologic survey of an area is usually begun after the topographic map has been completed, and that map is used as a base. Occasionally, however, the geologist works with the

topographer, or even at times works in advance of formal topographic mapping, but in such cases he is either supplied with some form of map, or himself constructs a rough topographic map as he works.

The field work of the geologist engaged in systematic geologic survey is ordinarily confined to examination of the surface, aided by magnetic observations in connection with magnetic ores. Samples of rocks and ores and specimens of fossils are collected. All mines or other available openings are also examined, but only in exceptional cases are independent borings made for this purpose. The field work is supplemented by office and laboratory work, which includes microscopic and chemical examinations of the rocks and ores collected and paleontologic study of the fossils.

The results of the geologic surveys are given to the public in reports accompanied by geologic maps, diagrams and other illustrations, and in "geologic folios" containing maps and descriptive text. These reports vary widely in scope and character, dealing in some cases with selected areas, in others with selected deposits, and in still others with particular geologic problems. They vary also in size and in the degree of technical knowledge assumed on the part of the reader. The shorter and less technical reports are published under the general name of Bulletins, those of intermediate character under the name of Professional Papers, and the more voluminous and technical treatises under the name of Monographs. The Bulletins and Professional Papers are distributed free for the public, while Monographs are sold.

More recently, the Survey has been issuing, as Bulletins, guidebooks to various parts of the western states, arranged according to the principal tourist routes. Although the geologic features of the country occupy a large part of the text, information is also given, in popular style, relative to the geography, including scenic features, notable historic events, Indian tribes, industrial resources and plants and animals.

A "geologic folio" is thus described by the Survey:²

A standard geologic folio comprises a descriptive text, in which the geography, topography, and geology of the area are described; a topographic map; a geologic map, printed in colors, showing the areal distribution of the geologic formations; a geologic map showing the deposits of economic value in stronger or more brilliant colors; a geologic map on which the underground structure of the rocks is exhibited by vertical sections representing what would be seen in deep trenches cut across the area; and a columnar section, in which the rocks are represented in a vertical column in their normal relation one to another, accompanied by a condensed description of their composition, thickness, and relations.

For special areas other maps or illustrations are included. Often it is desirable to present with the description a page of illustrations reproduced from photographs or sketches. For artesian-water areas the distribution of the water-bearing strata, the areas where flowing water may be obtained, and the depths to the water horizon are shown on a special sheet. For active mining regions a map on a scale sufficiently large to show important details of the geology, mines, and ore deposits is inserted. For coal regions of economic importance special methods are used to show the structure or lay of the coal beds—of so much importance to the mine worker. This is done by means of contour lines which show the elevation above sea of the coal bed throughout its occurrence in the area, and then furnish the data for determining the depth of the coal below the surface at any point. Sections of coal beds which have been opened or worked are shown on a large scale and their relation to one another is indicated.

Generally speaking, each folio relates to a single quadrangle, that term having the same meaning as when applied to a topographic map; but some folios cover two or more quadrangles.

Occasionally, the advance of geologic knowledge of a particular area, or the demand for more detailed information, necessitates a revision of maps already published.

The geologic survey now carried on discloses the distribu-

² The U. S. Geological Survey: Its Origin, Development, Organization and Operations, p. 99-100, 1904.

tion and thickness of the formations in the area covered, their chemical composition and physical characteristics, and their age—that is, the period of geologic time in which they were deposited, as well as their form—that is, their structure, and the geologic forces which caused their deposition, erosion, and deformation.

The value of facts regarding the mineral character of rock formations for the development of mineral resources need not be dwelt upon. In disposing of the public lands this information is useful not only in shaping policies but in administering the land laws, and such information concerning lands privately owned facilitates and expedites the development of mineral deposits of economic value, or indicates the non-existence of such deposits. In this connection it may also be pointed out that information as to rock formations incidentally includes information as to underground water.

The identification of the geologic positions of several strata in the geologic time-scale is also of value to the economic geologist, as it helps him to determine the probability of the occurrence, in the area, of particular economic deposits. Another value, however, lies in the light it throws on the relation of the geology of the area to that of adjacent areas and, ultimately, of the entire country.

The maps and descriptive texts resulting from geological surveys find a most important use in the hands of the Survey itself in its work of land classification and of geologic research.

It would be difficult to ascertain precisely the total amount spent by the Survey in geologic surveys of the country. The appropriations used have been made under various heads, and some have provided for other work than geological surveys. The total amount appropriated since 1889 for "geologic surveys in various portions of the United States" has been about \$5,500,000; that appropriated for paleontologic researches (an item of appropriation no longer in use), and for chemical and physical researches has been over \$900,000; and that ap-

propriated for "geologic maps of the United States" has been nearly \$2,500,000. To this there should be added a large part of the "lump-sum" appropriations made to the Survey during 1879-1888. It seems fair to conclude, therefore, that the geologic surveys proper, exclusive of surveys in Alaska, have cost nearly \$9,000,000.

Investigation of Mineral Deposits. In addition to its surveys of selected areas, the Survey makes many investigations and surveys with a view to determining the occurrence and distribution of the deposits of a particular mineral, or the mineral deposits in a particular area. Much of this work that is done on the public lands is a direct incident to the task of classifying or evaluating those lands under the land laws, and this phase of the work will be discussed in a subsequent section.

The investigations here considered are thus concerned only with a single class of mineral deposits. Though the Survey's work in Alaska has from the beginning been conducted under appropriations for the "investigation of the mineral resources of Alaska," no specific phrase of that kind has ever been used in appropriation bills covering investigations in the United States, which have been conducted under the general authorization for "geologic surveys." Investigations of this type are generally undertaken by the Survey with reference to a deposit of major importance in a field not yet adequately exploited. The Survey attempts to outline the limits of the area in which occurrences of the deposit may be expected, and to indicate the zones in which the richest deposits are likely to be found and the general conditions to be expected. An investigation of this type is the Survey's work on the oil shales of the Green Bay region.

The Survey also, when an unusual demand arises for any mineral product, makes a general investigation of the occurrence of that mineral. Investigations have thus been made of such minerals as monazite, zircon, iridosmine, platinum,

and all minerals possessing radio-active and radio-responsive products. More recently a systematic search has been made for new deposits of petroleum, phosphates, nitrates, potash, pyrites, and manganese.

For the proper conduct of exploratory researches of this kind, and indeed for the most effective collection of data relative to mineral deposits in the course of general geologic surveys, it is essential that the geologists conducting the operations be thoroughly versed in the technology of the production of the mineral sought.

Recognizing that the ability to form a correct judgment as to the practical utilization and value of an ore or other mineral deposit in the ground is most effectively acquired through the field observation of operating works and processes for the exploitation and reduction of the same or similar deposits, the Survey regards it of the highest importance that the geologists who may be called upon to appraise undeveloped mineral resources in the public domain or in other regions of the country shall keep as closely as practicable in touch with the mineral industry, and shall have a knowledge of the factors conditioning the successful treatment and utilization of the ores he is examining.³

The methods employed in searching for new deposits are not unlike those followed by private prospectors possessed of adequate funds and acting under the advice of trained geologists. If possible, coöperative arrangements are made with private parties who may be drilling in the areas selected for exploration or in adjacent areas by which the cores removed by their drills are turned over to the Survey for examination and report. This method has been employed most consistently in connection with the search for potash deposits which the Survey has been making for several years. Describing this coöperation, the report of the Director for 1915 states: ⁴

³ Report of the Director of the Geological Survey, 1915, p. 47.

⁴ P. 44.

Every effort is made to coöperate with all drillers who may be boring in the regions which are under examination or which it is thought may contain large saline deposits. Sample bags and specially prepared log books are furnished to them with the request that cuttings be taken from every "screw," at least in the regions of the formations containing or adjacent to the saline or gypseous deposits. Also samples of brines are solicited. All these samples are tested for potash in the laboratory of the Survey, and the drillers are informed as to whether potash is present in considerable amounts in any of the samples. In the lack of funds sufficient to carry on the exploration more rapidly and especially to conduct boring operations in several areas at once, the effort will be made, whenever possible, to station scientific observers at the sites of new drillings in areas which would appear to be especially promising or in which indications have been reported, in order that the cuttings of the drill may be watched on the ground by a competent observer and tests made of the samples and brines as the work progresses.

In addition to the explorations above described, the Geological Survey is testing all samples sent to it for examination from reported discoveries of potash salts or nitrates. It has also made field investigations of reported deposits concerning which the tests have been favorable, and the information submitted with the samples has warranted the hope that the deposits might prove to be of value.

Research in Geologic and Related Theory. In the Survey's researches for mineral deposits, as in all such researches made by trained geologists for private parties, the area of operations is selected and the operations themselves are guided by a hypothesis or theory relative to the occurrence of the mineral sought. It need hardly be added that the Survey, as the largest single organization engaged in such researches and in the collection of geologic data generally, is itself a prime factor in formulating and developing theories of mineral occurrence.

The Survey has from the first taken the position that a great and peculiar field of usefulness lies before it in this type of research.

The principles controlling mineral deposition and the laws governing the occurrence of ore bodies can be satisfactorily determined only as a result of the comprehensive study of many mines and mining camps. This work is beyond the reach of individuals but is appropriate to the national organization. The application of the principles to particular ore bodies and camps is quite within reach of the individual mining engineers charged with development work.⁵

In large measure geologic and mineralogic data that form a basis for researches of this type already exist in the results of the Survey's work. The search made for specific mineral deposits by the Survey also frequently contributes materials of considerable theoretic value.

The broad and searching observations which should accompany every piece of good economic work comprehend data that are eventually combined in the construction of new scientific hypotheses, some of which, as more observations accumulate, grow into established laws or principles that are in turn of the greatest practical consequence. Thus the detailed studies of the metalliferous deposits in one region or another bring to light evidence from which to determine the genesis of the ores and the modes or conditions of their occurrence.⁶

Both these classes of existing data must, however, frequently be supplemented by special studies in the field and in the Survey's laboratories. As illustrative of the Survey's chemical and physical researches may be mentioned extensive laboratory investigations of the diffusion of gold and silver into lead and tin, the linear force of growing crystals, the migration of natural oil in certain sands, and the enrichment of ores of silver, copper, etc.

The Survey's investigations of certain problems of mineral occurrence border closely upon investigations made by the Bureau of Mines in the field of mineral utilization. The Sur-

⁵ The United States Geological Survey: Its Origin, Development, Organization and Operations, 1904. Bulletin No. 227, p. 31 f.

⁶ Report of the Director, 1912, p. 16.

vey, for example, has studied the causes of the entrance of water into oil-producing sands, which has occurred on a large scale in certain oil fields, especially in California, with the result that large quantities of oil can never be extracted, and the Bureau of Mines has studied methods of remedying the evil and engineering devices for conserving the oil. In these joint studies the field to be covered by each bureau is clearly outlined and the work is carried out in a spirit of coöperation.

In addition to the investigations designed to develop the theory of the occurrence of some particular mineral, the Survey continuously prosecutes studies and investigations designed to develop general geologic theory. The purpose held in view by the Survey in studies and investigations of this kind was thus clearly stated by Major Powell in his testimony before the joint congressional commission of 1885-86.⁷

There are many investigations that may not at first seem to lead to economic results, but which ultimately and indirectly are of importance even for economic purposes. The scientific man, especially the geologist, for reasons which I have heretofore set forth, has to do with a vast complexity of problems. To select a part of these problems and work upon them may not lead to substantial results when other problems are neglected that have relation to the first. The whole body of research in geology has a very important practical value, because geologic investigation reveals the wealth buried beneath the surface of the earth. Sound geologic conclusions cannot be reached by following a few narrow lines of investigation, but all such lines of research must be followed that each may shed light upon the other. Unless this principle is fully recognized, a geologic survey might lead to conclusions of no value to the people at large, or conclusions might be reached so erroneous as to be misleading. It therefore often happens that in determining to inaugurate investigations in a particular line the one question asked is, "Are we likely thereby to discover facts that will shed light upon the general

⁷ Testimony before Joint Commission, 1885-86, Senate Misc. Decs., 49th Congress, 1st Session, Vol. 4, p. 700.

problems of geology?" feeling assured that ultimately all such research will be of economic value.

In the first decade of the Survey's existence its geologic work was largely devoted to the investigation of the broad problems of American geology, and the formulation of a fundamental geologic classification as the scientific basis for the preparation of the geologic map of the United States. As the major features of this basic problem approached solution, the Survey's attention was increasingly turned to the geological survey of the country. Researches in geologic history and theory have nevertheless been steadily prosecuted. Thus, for some time past the Survey has been engaged in a study of the work of glaciers, the geologic history of the continent during the Quaternary period, and the classification and correlation of the sedimentary rocks of the entire country, work involving the study of all North American fossil faunas and floras and their comparison with those of other parts of the world.

Broad geologic research may involve correlative research in physics and chemistry. Among the researches of this type carried on by the Survey are those relating to questions of terrestrial physics, such as the mechanics of the Panama Canal slides, the variation in the water content of rocks from Panama, the increase of earth temperatures with increase of depth, and the electric activity of ore deposits.

In addition to chemical and physical researches directly related to geologic researches, the Survey from time to time has made researches which may be said to be directed to the elucidation of general physical and chemical problems that have no exclusive relation to the development of geologic theory. Thus, work has been done by the Survey in a revision of the fundamental atomic weights, on the radio-activity of ores, and on the geochemical interpretation of water analyses. Much of the work now done by the Carnegie Geophysical Laboratory was begun in the Geological Survey.

Compilation of Information Relative to Mineral Deposits and the Mineral Industries. In addition to its activities in connection with the exploration of mineral deposits, the Survey collects, compiles and disseminates information relative to all known mineral deposits in the United States, and relative to the production of minerals.

The circumstances under which the Survey began in 1882 its publication of the annual report on the "Mineral Resources of the United States" are set forth in the preceding chapter. In 1905 authority was obtained from Congress (act of March 2, 1905, 28 Stat. L., 960) to publish the separate parts or chapters of this report in pamphlet form as soon as they were transmitted to the printer, it being provided that "the report of the Mineral Resources of the United States shall be * * * printed for each preceding calendar year *as soon as compiled and transmitted for publication*, and that the separate chapters on any given mineral product, such as iron, coal, building stone, and so forth, *shall be printed as rapidly as transmitted for publication.*" This act was passed only to insure prompt publication. "Advance chapters" had been issued long before this act was passed.

In early years, the work of the Survey in this field was confined largely to the compilation of statistics of production. More recently the tendency has been to emphasize the importance of data relative to the occurrence, technology and utilization of the mineral resources of the country. Simultaneously the effort has been to publish more promptly the statistics of production, and at present weekly, monthly and quarterly statistics regarding certain mineral products are being collected.

The collection of statistics showing the production of minerals in the United States involves a complete annual canvass of all the mineral producers, a complete list of whom is kept by the Survey. This canvass is made largely by correspondence, but is supplemented by field work. The technical press is also carefully scrutinized for new names. As a further

means of keeping the lists of producers up to date, the lists are printed every year and distributed to persons familiar with the industries for corrections and additions.

In the preparation of its statistical reports for the last six years, the Survey has worked in coöperation with a number of the state geological surveys, the statistics thus collected being used jointly by the state and federal surveys. This coöperative agreement avoids annoyance to the producers by duplicate requests for statistical information and insures more prompt and more complete returns. Eighteen state surveys are now coöperating in this way.

"Mineral Resources of the United States," which for several years has consisted of two volumes, is still the chief medium through which information concerning the country's mineral industries is made public. In addition to this annual compilation and the more frequent shorter periodical statistical statements given largely through the press, the Survey publishes from time to time a report on a particular mineral or group of minerals from material obtained in the course of its investigations. A type of these special compilations is a volume published in 1917, entitled, "Useful Minerals of the United States," giving the location, by states and counties, of the principal deposits of useful minerals, and a glossary showing the composition and character of each mineral, the location of its principal deposits and its chief uses. Among the more technical compilations may be mentioned a 67-page pamphlet on the "Antimony Deposits of Alaska," and a slightly larger paper on "Tungsten Minerals and Deposits." The Survey has also published from time to time in its reports special maps showing the distribution of the deposits of particular minerals.

The Survey's various publications are supplemented by extensive correspondence with the general public. The Survey is at all times ready to give available information to those inquiring into the occurrence and utilization of mineral substances. In this connection the report of the Director for

1916 says that the Survey "is becoming more and more a repository of information concerning the mineral resources of the country, much of which it furnishes through correspondence, giving detailed information which cannot be covered by publications, such as the location of deposits of minerals, both those that are developed and those that are undeveloped, and names of those who can supply the different minerals."

The numerous problems raised since the beginning of the war by the shortage of basic minerals have resulted in an unprecedented demand on the part of other agencies of the government for exact data as to the occurrence, production and utilization of these minerals. This demand the Survey has been able to meet by reason of its unique accumulation, over many years, of data of this type, and its trained organization ready to obtain new classes of data as new demands have been made for them.

Survey of Water Resources. In the course of its topographic and geologic surveys, and of its search for mineral deposits, the Survey, needless to state, collects a vast amount of information relative to the water supplies of the country; and its resulting topographic and geologic maps are of the highest value to one investigating the utilization of the water resources of any area covered by them. The Survey supplements the data collected and published in this connection, which have reference primarily to the location of the surface water supplies, with a survey designed to disclose also their quantity and quality, and to locate sources of underground supply.

The specific investigation of water resources by the Survey dates from the appropriations made in 1888 and 1889 for the investigation of the arid public lands and the extent to which they can be reclaimed by irrigation. The operations under those appropriations and the failure of Congress to make special appropriations for them between 1889 and 1894 were re-

viewed in the preceding chapter. The investigation of water resources, however, was carried along on a small scale by special arrangements until 1894, when an appropriation authorized its extension to the whole country, and since that time the work has progressed steadily. The maintenance of hydrographic work on its present scale is made possible in large measure by substantial contributions made to the work by many of the states.

The operations embraced in the survey of water resources may be grouped under three heads—the location of supplies, the measurement of their quantity and the investigation of the practicability of their utilization. These operations vary essentially according as they deal with surface or ground waters.

Surface Waters. The location of streams and springs is of course determined by the regular topographic surveys. Their quantity is determined by measuring their flow through a period of years sufficiently long to ascertain definitely the limits of variation, by maintaining stream-gaging stations over all the country, but particularly in the West. During the year ending June 30, 1917, nearly 1,200 such stations were maintained, but only thirty-six of them by the Survey alone, the others being maintained, in coöperation with the Survey, by various bureaus of the government (the Reclamation Service, the Forest Service, the Indian Service, the Weather Bureau, and others) and by states, cities and private persons. At these stations daily measurements of stream height are made, and periodic measurements of the flow or discharge. During the fiscal year 1917 an average of over six measurements of discharge were made per gaging station.

In addition to the data thus collected to determine the quantity of surface waters, analyses are made to determine their suitability for domestic, irrigation, boiler and other uses. In this work samples are usually taken from the stream daily for one year, united in sets of ten consecutive samples and the composite samples analyzed. The results of the analyses,

when correlated with records of discharge, show the variations in character of the water with changes in discharge and seasons. They also furnish the basis for classifying the water for irrigation, domestic, and various industrial uses.

For the publication of the results of stream measurements the country has been divided into twelve primary drainage basins, and an annual progress report is published separately for each of these basins. For the publication of the data as to quality of water, utilization of streams, and other special data, no fixed territorial basis is used. Most of the data concerning either surface or ground water are now published in the Survey's series of "Water Supply Papers." Occasionally the study of the water resources of an area for a special purpose, as municipal water supply, results in a publication covering both surface and ground waters in the area studied.

The Survey's investigations of surface waters are put to numerous and important uses. They furnish valuable, and concerning some streams, absolutely indispensable data needed in the consideration and development of irrigation, power, water supply, navigation, and flood protection projects. Their results have been of high value in connection with the irrigation of the arid lands of the West. The location of reclamation projects not only by the national government but by state and private enterprise has for the greatest part been guided by the data gathered by the Survey. Less well known but hardly less important is the part which the Survey's findings have played in aiding power development on the streams of the country.

It is difficult to define in terms of time or of magnitude the entire project of surveying the surface waters of the country, and it is indeed to be questioned whether the work may properly be regarded as definitely terminable, for it is not yet apparent that a point will be reached when the collection of stream measurements and the analyses of water will become unnecessary; on the contrary it is believed that this work, like the collection of climatic data, must be continued indefinitely.

With these limitations in mind, it may be stated that stream measurements covering a period of years are now available for 4,000 points on the streams of the country. The collection of data as to the quality of surface waters has made less progress. Reports including data on the quality of the surface waters in nearly every state have been published, though only six reports cover the quality of surface waters of entire states, and these reports consider only the principal streams. In general, it may be said that most of the principal streams of the country have been investigated for their quality, but these streams constitute a very small percentage of the total surface water supplies of the country.

Ground Waters. The location of ground waters is essentially a geologic problem and is determined principally by geologic methods. It involves an examination of the strata in the region explored and the determination of the position, character, and capacity of those that are water-bearing. These geologic methods give results that are in the nature of forecasts. Drilling is necessary to determine with certainty the yield, head, and quality of the waters sought, but until the fiscal year 1917-18, the Survey did no test drilling for this purpose. The appropriation act for that year provided that of the \$175,000 appropriated for water resources investigations, \$25,000 might "be used to test the existence of artesian and other underground water supplies suitable for irrigation in the arid and semiarid regions by boring wells." It will be noted that this provision includes only supplies suitable for irrigation. Under this authorization the Survey has begun drilling in a desert area in Nevada where the geologic conditions are believed to be favorable, and has already discovered a large supply of water that will be available for irrigation.

The determination of the quantity of ground water in any given area is difficult. In some areas it is practicable to measure the flow of the ground water by electrical apparatus inserted in test holes or to make estimates based on the ob-

served fluctuations of the water table, which represent the filling or emptying of the underground reservoir. In other areas it is practicable, by observation of surface conditions, to determine approximately the quantity of water that annually enters or is discharged from the underground reservoir. These observations comprise stream measurements to ascertain the quantities of surface waters that percolate into the ground, and measurements of the discharge of ground water through springs and by evaporation from soil and plants. These methods are laborious and difficult and none of them are likely to afford precise results, but they are nevertheless valuable, because they give a tangible basis for estimating the supplies of ground water.

In addition to determining the quantity and quality of the waters a survey of ground waters discloses important factors affecting the practicability of recovering them, such as hydrostatic pressure and the nature of the rock to be encountered in sinking wells. The investigation of these elements is involved in the study of the local geology, which is supplemented by examinations and tests of the existing wells in the area surveyed.

The data gathered as to sources of ground water are naturally of value chiefly in the arid and semiarid regions of the West, where such supplies are needed both for domestic use and for irrigation, but the importance of deep ground water supplies over the whole country is being emphasized. It is highly desirable to obtain supplies of domestic water from sources other than the shallow wells, some of them open, that are sunk near many houses. The water obtained from deep wells has percolated through sands and other material for so great a distance that its impurities have been removed by filtration, and it possesses a sanitary value that cannot well be overestimated, for it is free from the bacteria that cause typhoid fever and the protozoa that cause amoebic dysentery, and its use obviates the necessity for shallow wells that may

serve as a breeding place for *Anopheles*, the mosquito to which malarial infection is due.

Altogether the Survey has accumulated a vast amount of accurate data of both scientific and economic value on the ground waters of the United States. A total of 474 papers has been published relating in some way to ground water, of which 271 papers relate primarily to this subject. Many of these papers include detailed maps showing the ground-water conditions in specific areas. In addition to the data already published there is a great quantity on file at the Geological Survey still unpublished.

About 75 per cent of the area of the United States (excluding Alaska and the Insular Territories) has been covered by ground-water surveys of some sort, and about 25 per cent has been covered by what may be called standard ground-water surveys. The total area covered by intensive surveys is very small, amounting to only a fraction of 1 per cent of the total area of the United States.

The Survey for some years has published in its water supply papers notes on desert watering places, but in 1917 a specific appropriation of \$10,000 was granted by Congress "for discovering, developing, protecting, and rendering more accessible, springs, streams, and water holes on arid public lands of the United States; for erecting and maintaining suitable and durable monuments and sign-boards; and for providing convenient and ready means, apparatus, and appliances by which water may be brought to the earth's surface." The Survey has devoted the funds thus appropriated to prosecuting more vigorously than has hitherto been possible the survey of watering places, and to preparing guides and maps, and erecting sign-posts directing to them.

The total area sufficiently arid to require maps and guides to desert watering places is about 570,000 square miles, or nearly one-fifth of the area of the United States, exclusive of Alaska and the Insular Territories. Of this area about 75,000 square miles have been surveyed since July 1, 1917,

and additional areas of approximately the same aggregate extent are covered by older guides to desert watering places. The region to be covered lies east of the Cascade and Sierra Nevada Mountains and west of the following cities: Boise, Twin Falls, Salt Lake City, Grand Junction, Santa Fé, Roswell, Pecos, and Fort Stockton. The area has been tentatively divided into twenty-six districts, for each of which a guide is ultimately to be prepared. The preparation of maps and guides and the erection of a fairly adequate number of sign-posts for the entire area will cost about \$100,000. It is hoped that this work can be done within the next few years.

Investigation in Problems of Water Utilization and Control. From time to time the Survey undertakes the investigation of large problems of water utilization and control. The early investigations made by the Survey into the problem of irrigating the arid lands of the West, and the more systematic work of the Powell Irrigation Survey, in 1888-90, have already been mentioned. It is worthy of note that in his report for 1888, in discussing the problem of irrigation, Major Powell adverted also to the possible reclamation of the flood plains of the lower Mississippi valley by the control of the headwaters of that stream and its chief tributaries. A problem closely akin to this was brought expressly within the province of the Survey by the act of 1908, to which more extended reference will be made in the next section, imposing upon the Survey the duty of examining forest lands proposed to be purchased by the government for the prevention of floods on navigable streams.

While one or another problem of water utilization or control has thus from time to time been brought within the purview of the Survey's activities, no express authorization to investigate generally problems of this type has ever been conferred by statute. Such investigations as are currently carried on are conducted under the general authorization to investigate "the water resources of the United States."

Illustrative of the type of investigation undertaken by the Survey in this direction are the continuing investigations of the problems of flood prevention and of reclamation of marsh and swamp lands, and the special investigation of the hydraulic mining debris problem. The investigation last mentioned, one of the most extensive and original of those made in this field by the Survey, was undertaken at the request of the California Miners' Association with a view to devising measures whereby the interests of agriculture and navigation in the streams carrying mining debris could be harmonized with those of the placer mining industry. The investigation by the Survey, which extended over more than ten years, involved research in the existing literature on the subject, laboratory study of the laws of transportation of detritus by running water, and a field examination of the entire course of the Sierra Nevada River. The report of this investigation, which was published in 1917, recommends a coöperative control by all the major users of the Sierra's water whether for mining, irrigation, or power development.

Examination Under Act of March 1, 1911, of Land Proposed to be Purchased by the Government for Protection of Navigable Streams. The act approved March 1, 1911, known as the Weeks Act, which provides for the acquisition of land for the purpose of conserving the navigability of navigable streams, imposed a new duty on the Geological Survey. The lands to be purchased must be selected by the National Forest Reservation Commission, but under section 6 of the act they may be purchased only after the Geological Survey has examined them and submitted a report on them to the Secretary of Agriculture "showing that the control of such lands will promote or protect the navigation of streams on whose watersheds they lie." The law thus places upon the Geological Survey the responsibility of determining the fundamental question whether the control of any specific tract of land will promote or protect navigability, and stipulates that

a favorable report to the Secretary of Agriculture must precede the purchase of the tract considered.

Following is a description of the methods employed in beginning this work as contained in the annual report of the Director of the Survey for 1911:

On the initiative of the Survey a conference was arranged between representatives of the Department of Agriculture and of the Department of the Interior, and an agreement was reached concerning procedure in the administration of this new law, so far as the Forest Service and the Geological Survey are concerned, to the end that the examinations of land by the two bureaus might be coördinated. In this agreement, which was approved by the two Secretaries on May 3, 1911, it is set forth that the examination by the Geological Survey will include the determination of the relation of the headwater streams to the navigable streams to which they are tributary, the local observation of the headwater stream or streams draining the tract or tracts in question with reference to run-off characteristics and to nature and amount of suspended material, the classification of the surface formations of the tract with reference to permeability and storage capacity and to resistance to erosion, and the securing of such additional topographic data, in coöperation with the Forest Service, as are needed by the two bureaus in their examination of the tract.

The greater part of the examinations necessitated by this act were completed within the first two years after the passage of the act, but other examinations have since been made from time to time.

Investigation of the Character and Value of Public Lands Made Necessary by the Public Land Laws. As has been seen in the preceding sections, the surveys and investigations made by the Survey, though they extend over the whole country, have in large measure related to what may be termed the public land region of the United States. Indirectly, therefore, the Survey's general work has had and continues to have a far-reaching influence upon the development of the public

lands. In addition, however, the Survey aids materially in the actual administration of the public land laws, for it is called upon to investigate the mineral and water resources of specific areas of the public land, as well as to determine the value of certain tracts, and to recommend to the Secretary of the Interior or the General Land Office the designation or non-designation of each tract in such areas as falling under one or another of the statutes governing the public lands. Moreover, on occasion, it is charged with the drafting, for the approval of the Secretary of the Interior or the President, of further regulations for the administration of these laws.

Origin and Development. For a decade or more before the creation of the Survey, Congress, by legislation for the disposition of the public lands, had in increasing degree drawn distinctions between the several types of land. The homestead law of 1862 had expressly excluded mineral lands from its provisions. Every grant to a railroad, beginning in 1862 and ending in 1871, excluded from the grant all lands containing minerals other than coal and iron. In the decade 1865-1875 were enacted the basic provisions governing the disposition of mineral lands. In 1873 was enacted the coal land law, which provided not merely for the sale of coal lands under special provisions, but, inferentially at least, for their evaluation before sale. In 1877 still another novel distinction was introduced into the land laws by the enactment of a provision for the sale of desert lands.

Despite the existence of these special provisions relative to the disposition of desert, timber, mineral and coal and iron lands, neither the statutes nor the machinery of the Land Office made any provision for the independent determination by the government, in advance of sale, of the character of the lands to be sold. The sole method employed was that of proof offered by the entryman or claimant and subject to challenge before the officers of the Land Office.⁸ The results

⁸ "At present the General Land Office possesses the machinery for the survey, classification, and sale of the public lands. In that bureau the field-notes and maps of the various deputy surveyors are intended

secured by this method were thus characterized by Major Powell, subsequently Director of the Geological Survey, in 1878, the year before the Survey was created: "No adequate provision is made for securing an accurate classification, and to a large extent the laws are inoperative or practically void; for example, coal lands should be sold at \$10 or \$20 per acre, but, the department having no means of determining what lands belong to this class, titles to coal lands are usually obtained under the provisions of statutes that relate to lands of other classes—that is, by purchasing at \$1.25 per acre, or by homestead or preëmption entry."

Major Powell was accordingly of the opinion that "an examination of the laws will exhibit this fact—that for the classification contemplated therein a thorough survey is necessary, embracing the geological and physical characteristics of the entire public domain." The National Academy of Sciences, to which Major Powell had expressed this opinion, and which, as already stated in the outline of the origin of the Survey, had been requested by Congress to investigate the entire subject of government surveys, reported that "to meet the requirements of existing laws in the disposition of the agricultural, mineral, pastoral, timber, desert, and swamp lands, a thorough investigation and classification of the acreage of the public domain is imperatively demanded. The Land Office shall also call upon the United States Geological Survey for all information as to the value and classification of lands."

In the act creating the Geological Survey, as already stated, Congress provided that it should have charge of the "classifi-

to convey sufficiently accurate information for the general guidance of the officers who execute the sales. The law also provides a method of proof as to the character of lands, which forms an indispensable stage in the process of sale. Any transaction as to a piece of public land may be challenged before the proper officers, and its character may be determined by competent proof. The present method of sale of the public lands depends, therefore, chiefly upon a rule of law rather than the classification of experts in advance of the procedure of sale." First Annual Report of the Geological Survey, 1880, p. 5.

cation of the public lands." In the same act, however, provision was made for the creation of a commission of five members, of whom the Director of the Geological Survey was to be one, to report to Congress "first, a codification of the present laws relating to the survey and disposition of the public domain; second, a system and standard of classification of public lands, as arable, irrigable, timber, pasturage, swamp, coal, mineral lands, and such other classes as may be deemed proper, having due regard to humidity of climate, supply of water for irrigation, and other physical characteristics; third, a system of land-parceling surveys adapted to the economic uses of the several classes of lands; and, fourth, such recommendations as they may deem wise in relation to the best methods of disposing of the public lands of the western portion of the United States to actual settlers." The commission appears to have given consideration to the practicability of a classification of the public domain in advance of disposition, and to have decided adversely to any change in the existing practice in this regard.

Accordingly, the Director of the Survey stated in his first annual report:

Upon examination of the existing land system, I have assumed that Congress, in directing me to make a classification of the public lands, could not have intended to supersede the machinery of the Land Office, and substitute a classification to be executed by another bureau of government, without having distinctly provided for the necessary changes within the Land Office, and adjustment of relations between the two bureaus.

I have therefore concluded that the intention of Congress was to begin a rigid scientific classification of the lands of the national domain, not for purposes of aiding the machinery of the General Land Office, by furnishing a basis of sale, but for the general information of the people of the country, and to produce a series of land maps which should show all those features upon which intelligent agriculturists, miners, engineers, and timbermen might hereafter base their operations, and which would obviously be of the highest value for all stu-

dents of the political economy and resources of the United States. Studies of this sort, entirely aside from the administration of the Land Office, can be made of the highest practical value.

The position thus taken at the beginning of the Survey's history was acquiesced in by Congress, which took no steps to modify the wording of the statute. Special duties, involving the administration of the public lands, were indeed from time to time temporarily imposed upon the Survey. Such were the duties exercised in 1888-91 with respect to the reservations of reservoir sites and irrigable lands, in 1896-1905 in the examination of the forest reserves, and in 1902-07 in the administration of the reclamation act. Aside from these exceptional functions, however, it may be said that until about 1906 the Survey remained almost wholly detached from the administration of the land laws.

In the years 1905 and 1906 the general public began to realize that large areas of valuable coal lands in the West had been obtained from the government by means of agricultural entries. The frauds thus perpetrated were so great as to shock the public mind and to call for some immediate action to prevent further similar looting. Accordingly, the President, on June 29, 1906, directed the Secretary of the Interior to withdraw from entry all valuable coal lands. The Survey had previously been making special studies of certain western coal fields and its geologists had assisted in unearthing some of the coal frauds. It was, therefore, prepared to submit a list of lands which should be withdrawn from entry, and on July 26, 1906, the Acting Secretary of the Interior withdrew from all forms of entry all the lands on the list submitted by the Survey. There was thus set in motion a train of legislative and administrative action extending over several years by which the entire system of disposing of the public coal lands was revised and placed upon the basis of a valuation by the Survey before disposition. The work of evaluating these lands is still in progress by the Survey.

In the following year the Survey made recommendations to the Secretary for the withdrawal of oil and gas lands, and in 1909 of potash lands pending legislation for their disposition. In the same year the Survey's activities in this field were extended to lands containing water-power sites and in 1912 to public water reserves, that is, water supplies necessary for the utilization of the public range, and still later to phosphate lands, oil-shale lands, and lands suitable for designation under the enlarged homestead laws. All this classification work was undertaken, and is still continued, without express legislative warrant other than that contained in the original act of 1879. In 1917, however, Congress made an appropriation of \$150,000 "for the examination and classification of lands requisite to the determination of their suitability for enlarged homesteads, stock-raising homesteads, public watering places, and stock driveways, as required by the public land laws,"—the first specific appropriation for land classification work ever made to the Survey.

Legal Provisions Applied in Land Classification. For an understanding of the methods employed by the Survey in land classification work, some knowledge is necessary of the provisions of law towards the execution of which that work is directed. These provisions are too numerous and intricate for analysis here, but in their relation to the classification problem of the Survey they may be said to fall into two classes—those involving a determination of the mineral resources of the particular tract involved, and those involving a determination of its relation to the available water supply. In the first class fall those provisions requiring a determination as to whether the land contains minerals. If it does it is not open to homestead entry nor may it be taken under a railroad grant (unless it contains only coal and iron) or under a grant to a state. It is open to entry only under special laws, which, however, vary according as the land contains coal or other minerals. In general, these special provisions affect only the extent and character of the right acquired by the entryman or

patentee and the requirements of settlement or payment to be met by him. But in the case of coal lands a special provision permits and inferentially requires the valuation of the lands previous to their sale.⁹

The provisions of law involving a determination of the relation of the tract in question to the available water supplies are of three distinct classes—those relating to entries upon arid tracts by individuals, those relating to rights of way for irrigation, power or water supply purposes, and those relating to grants of irrigable lands to the states.

Under the desert land laws entries are permitted upon lands not capable of producing crops without irrigation, while under the enlarged homestead laws homestead entries of 320 acres may be designated by the Secretary of the Interior upon lands not susceptible of irrigation at a reasonable cost from any known source of water supply; and additional privileges are extended in certain cases to tracts which have not upon them such a sufficient supply of water suitable for domestic purposes as would make continuous residence upon them possible. The act of December 29, 1916 (39 Stat. L., 862) authorizes the Secretary of the Interior to designate as "stock-raising lands," open to homestead entries of 640 acres, lands chiefly valuable for grazing and for raising forage crops.

Various acts provide for the grant of right-of-way permits over the public lands for canals, ditches and reservoirs for irrigation and for mining and milling purposes; for power development and transmission, and for municipal water sup-

⁹ The law (sec. 2347 of the Revised Statutes) provides that "every person above the age of twenty-one years, who is a citizen of the United States, or who has declared his intention to become such, or any association of persons severally qualified as above, shall, upon application to the register of the proper land office, have the right to enter, by legal subdivisions, any quantity of vacant coal lands of the United States not otherwise appropriated or reserved by competent authority not exceeding one hundred and sixty acres to such individual person, or three hundred and twenty acres to such association upon payment to the receiver of not less than ten dollars per acre for such lands where the same shall be situated more than fifteen miles from any completed railroad, and not less than twenty dollars per acre for such lands as shall be within fifteen miles of such road."

plies. Action upon application for rights of way for these purposes obviously requires a determination of the feasibility of the project and the limits of the right of way required.

Under the Cary Act the Secretary of the Interior is authorized to contract with any state in which there are arid public lands for the reclamation of such lands by the state, and for their patent to the state upon satisfactory proof that an adequate supply of water for reclamation has been developed.

In the administration of the foregoing provisions it is frequently necessary also to apply the provisions of the so-called separation acts, the purpose of which is to permit the alienation separately of the values of a tract for the several purposes—agricultural, mineral or water—of which it may be susceptible of use.¹⁰

As against all these acts making provision for the disposition of the public lands, there is the general act of June 25, 1910 (36 Stat. L., 847) providing for the withdrawal from entry of any of the public lands in the discretion of the President. It is provided that "the President may at any time, in his discretion, temporarily withdraw from settlement, location, sale, or entry any of the public lands of the United States, including the District of Alaska, and reserve the same for water-power sites, irrigation, classification of lands, or other public purposes to be specified in the orders of withdrawals." By another act of the same date similar, though more limited, provision was made for withdrawal of lands within Indian reservations. Previous to the enactment of these acts, however, the power of withdrawal of lands from entry had long been exercised by the President without specific statutory warrant.

¹⁰ In addition there might be mentioned the reclamation act, the application of which requires a determination in connection with each project, not merely of the lands irrigable by the proposed works, but of the size of tract within each portion of such lands required for the support of a family. Special acts also grant rights of way for irrigation, power and municipal water supply purposes over the national forests. These acts are administered, however, by the Reclamation Service and Forest Service, respectively, without reference to the Geological Survey.

The principal purpose for which the power of withdrawal is now exercised, besides that of classification, is that of reserving from alienation public lands of special value, for the disposition of which Congress has made no adequate provision. At the present time oil, gas, potash and phosphate lands, and water-power and reservoir sites are being withheld from entry pending legislation. Some of the tracts involved have been thus withheld from entry since 1908.

The power of withdrawal may also be exercised to create permanent reserves in the public lands. Thus, several so-called public water reserves have been created in the great semiarid grazing areas of the West for the protection of the public range. In addition large petroleum reserves have been set up to insure an adequate supply of fuel oil for the Navy.

The determination of withdrawals, whether permanent or merely pending legislation, obviously requires an examination and classification of the lands to be reserved in the same manner as if the lands were to be thrown open to entry.

Under present practice, the work of investigation and evaluation carried on by the Survey is of two distinct kinds—the one the systematic and comprehensive examination and classification of large areas, the other merely that of rendering to the Land Office reports upon particular cases before it.

Systematic Classification. In the systematic classification of an area there is generally sought to be determined not the classification of each tract under each of the land laws but only under some particular provision of law, or for some specific contemplated withdrawal. Thus, the examination of an area may be undertaken solely to determine which of the tracts involved are phosphate lands. It may thus be found necessary, from time to time, to reexamine and classify, with respect to a particular provision, an area already examined one or more times for classification with respect to other provisions.

Up to the present time, systematic classifications have been attempted of coal, oil and gas, phosphate and potash lands, of

lands suitable for enlarged and stock-raising homesteads, of water-power and reservoir sites, and of public water reserves. A systematic classification of oil-shale lands has been undertaken and is still in progress, such lands being, however, classified only as mineral. No systematic classification has been attempted of mineral lands generally¹¹ or of desert lands.

The first step in the systematic examination and classification of an area thought likely to contain mineral or water resources, bringing it under special provisions of law, involves several distinct stages—that of withdrawal of the lands from entry pending classification, that of examination and classification, and, in the case of coal lands, evaluation, and that of restoration of the lands to entry.

Withdrawals for purposes of classification are recommended by the Survey as soon as it finds probable cause for believing that a given area contains lands falling under any of the special designations above referred to as calling for systematic classification. The facts upon which such belief is based may result from the Survey's own explorations or may be communicated by private parties, or may come to the attention of the Survey through news of the discovery of mineral deposits in areas not hitherto thought to contain such deposits.

The recommendations of the Survey as to withdrawals are made direct to the Secretary of the Interior, who, in turn, refers them to the President with his recommendations.

The extent of field examination found necessary for the classification of an area depends of course upon the amount of data already available to the Survey as a result of investigations previously made by it in the area, whether for classification or for other purposes, or those which may have been made by the field force of the General Land Office. Generally speaking, a previous systematic geological survey of an area

¹¹ By act of June 25, 1910 (36 Stat. L., 739) special provision is made for the classification of the lands within the Northern Pacific Railroad grant with respect to their mineral or non-mineral character. Work under this provision has been in progress since 1910.

will not obviate the necessity of field examination for classification.

As soon as possible after a withdrawal has been made, detailed examination of the withdrawn area is begun.

The classification of the individual tracts is controlled in large measure by standard regulations previously formulated by the Survey.

The regulations applying to the several types of mineral land generally define the amount of the given mineral which the tract must be estimated to contain to warrant its classification as such land. The regulations applying to coal lands necessarily go further and prescribe in the greatest detail the factors to be considered in evaluating such lands.

The technical methods used in the field examinations made for classification necessarily vary in accordance with the mineral or water supply whose presence is in question; and as they have been very fully set forth by the Survey in a publication issued in 1913,¹² they will not be described here.

In general, the results of the Survey's classifications are recorded in such form as to be available only for the use of the Survey, the General Land Office and the Office of the Secretary of the Interior. For its enlarged homestead designations, however, the Survey has printed maps showing the tracts designated.

As soon as an area has been classified, recommendation is made to the Secretary for the restoration to entry of the lands found not to fall within the provisions of the law. The lands falling within such provisions are either restored to entry under those provisions or are reserved from entry under the withdrawal act.

The classifications made by the Survey are accepted by the General Land Office as controlling, with respect to certain types of classification by order of the Secretary and with respect to others by practice. The classification by the Survey

¹² U. S. Geological Survey, Bulletin 537, The Classification of the Public Lands, p. 50 ff.

does not, however, in any way impair the legal right of an entryman to contest before the Commissioner of the General Land Office or the Secretary the propriety or accuracy of the classification.

The progress up to June 30, 1917, of the systematic classification of lands classified and restored to entry under such classification may be seen from the following:

Lands classified as	Acres
Coal lands	21,226,708
Oil-shale lands (classified as mineral lands)	3,992,036
Mineral lands in Northern Pacific Rail- road grant in Idaho and Montana	224,218
Lands suitable for enlarged homesteads	275,633,861

The status on June 30, 1917, of lands withdrawn from entry either permanently or pending the enactment of legislation for their disposition is as follows:

Withdrawn as	Acres
Oil lands	6,348,640
Potash lands	130,629
Phosphate lands	2,506,398
Water-power sites	2,429,097
Reservoir sites (valuable principally for the storage of water for irrigation)	80,251
Public water reserves	201,708

These figures, it should be noted, include under each class all lands now withdrawn from entry. The lands so withdrawn, however, have not all been examined and classified, and are, therefore, subject to restoration to entry should they be found, on examination, not to fall in the class indicated.

Classification on Applications. The classifications made by

the Survey of tracts with respect to which entries or applications have been filed in the Land Office now cover virtually all applications for and entries upon lands not yet classified, except homestead and desert land entries, metalliferous mineral entries, and coal land applications, the investigation of which, both in office and field, is made solely by the General Land Office.

In its land classification work on applications the Survey makes no field examinations but merely renders an opinion to the General Land Office on the basis of the data already on hand. If these data be inadequate, the necessary field examination is made by the General Land Office itself.

Operation of Lithographing and Engraving Plant. The operation of a lithographing and engraving plant is listed as one of the activities of the Survey, since this plant is operated not only for the execution of work for the Survey itself, but for other branches of the government as well. The policy of executing work for other services of the government has been adopted in order that the plant of the Survey may be maintained on the scale necessary to perform economically its own special work, to keep its equipment and personnel more continuously employed, and to make possible the concentration of a large force for emergency work for the Survey and for other government bureaus or offices as the demand may arise. The report of the Director of the Survey for the year 1917 shows that a large quantity of lithographic work of great variety was performed for the Government Printing Office in printing maps to be incorporated in publications of many departments of the government. Much work was also done directly for other departments and bureaus. The value of the work thus done directly or indirectly for other branches of the government amounted to about \$97,000, for which the Survey's appropriation for engraving and printing geologic maps was reimbursed by transfer of credit on the books of the United States Treasury.

A small amount of work, totaling about \$550, involving the reproduction, for publication, of Survey maps, was also done for eleven organizations and companies. The money received for this work is turned over to the Treasury to be credited to miscellaneous receipts.

The total number of copies of all kinds of engraved and printed matter produced during the year 1916-17 was 3,338,028, requiring 9,805,217 impressions.

CHAPTER III

ORGANIZATION

The primary divisions of the Survey are six, and are known as branches. They are:

1. Administrative Branch
2. Topographic Branch
3. Geologic Branch
4. Water Resources Branch
5. Land Classification Board
6. Publication Branch

Administrative Branch. The Administrative Branch includes all divisions carrying on all the general business of the Survey that is not included in the technical, scientific and publication work. It is composed of two offices:

1. Office Proper of the Director
2. Office of Chief Clerk

The Director is by law the administrative and scientific head of the Survey, reporting officially to the Secretary of the Interior, directing all scientific work, and being generally responsible for the organization and operation of the service. The Director spends a part of his time in the field exercising a general oversight of the Survey's field work. In his absence his administrative duties are performed by a geologist who is designated as Acting Director.

The chief clerk is the officer having direct charge of, and responsibility for, the conduct of the administrative work of the service. For this work his office embraces five divisions which, with their sections, are as follows:

1. Office Proper of Chief Clerk
2. Executive Division
 - a. Office of Chief of Executive Division
 - b. Mails, Records and Files
 - c. Appointments
 - d. Addressograph, Multigraph and Mimeograph Section
3. Division of Accounts
4. Library
5. Messenger Force

The Executive Division has charge of appointments, mails, records and files. The Division of Accounts has supervision of administrative bookkeeping, property accountability, purchases, express and freight. Of the 934 permanent employees of the Survey on June 30, 1917, 60 were employed in the Administrative Branch.

Topographic Branch. The Topographic Branch conducts the topographic surveys and prepares the originals of the topographic maps. The manuscripts of the several publications on spirit leveling and other topographic subjects are also prepared by this branch. The branch is administered by the chief geographer.

On June 30, 1917, the Topographic Branch comprised 166 of the 934 employees of the Survey.

For purposes of supervision and administrative control, the branch is divided into seven divisions:

1. Administrative and General
2. Atlantic Division
3. Central Division
4. Rocky Mountain Division
5. Northwestern Division
6. Pacific Division
7. Division of Military Surveys

Each of the five territorial divisions has a geographer in charge who reports to the chief geographer. Each geographer in charge has supervision of all field and office work on the topographic maps prepared in his division. Each division maintains headquarters in the field during the field season, the chief geographer and most of his force returning to the Washington office at its close for the execution of work of preparing the maps for publication. Inspectors, whose functions are to examine field work in progress and to aid in the maintenance of high and uniform standards, assist the chief geographer in the technical supervision of the work of the branch.

The operations of this branch do not extend to Alaska, all topographic work in that territory being carried on by the Division of Alaskan Mineral Resources in the Geologic Branch.

Geologic Branch. The Geologic Branch of the Survey is under the charge of the chief geologist. The number of employees under his direction on June 30, 1917, was 245, the largest number employed in any of the six branches of the Survey. In addition to this number 61 persons, most of them geologists, were employed occasionally by this branch. It is organized in four divisions:

1. Division of Geology
2. Division of Chemical and Physical Research
3. Division of Mineral Resources
4. Division of Alaskan Mineral Resources

Division of Geology. The Division of Geology is under the immediate direction of the chief geologist, who is also head of the Geologic Branch.

The division is organized into sections corresponding to the several types of field and research work it performs. These sections do work in areal, glacial and coastal plain

geology, paleontology, and metalliferous, non-metalliferous, coal, oil, and gas deposits. Each section maintains its own field parties, which, while giving attention in their examination primarily to the special province of the section, also gather data relative to the general geology of the areas examined. Thus, while the sections on areal geology are primarily responsible for the determination and mapping of the areal geology of the regions they examine, they receive assistance from other sections in their work in areas with which those sections come into special contact. The sections of the division are as follows:

1. Administrative and General
2. Section of Eastern Areal Geology
3. Section of Western Areal Geology
4. Section of Coastal Plain Investigations
5. Section of Glacial Geology
6. Section of Paleontology and Stratigraphy
7. Section of Geology of Metalliferous Deposits
8. Section of Geology of Non-Metalliferous Deposits
9. Section of the Geology of Eastern Coal Fields
10. Section of the Geology of Western Coal Fields
11. Section of the Geology of Oil and Gas Fields

The two sections of Areal Geology perform reconnaissance and detailed work in areal or general geology, in pursuance of the plan to complete the geologic atlas of the United States. The Sections of Eastern and Western Areal Geology make investigations east and west of the one hundredth meridian, respectively.

The Section of Coastal Plain Investigations carries on a study of the geology of the Atlantic and Gulf coastal plains of the United States, with special reference to their geologic history, giving particular attention to investigations of the stratigraphy, paleontology, and origin of the various formations.

The Section of Glacial Geology is engaged in the study of the glaciated area, the mode of action and the results of the action of glaciers, the glacial and interglacial deposits and the contemporary deposits of the regions bordering the glaciated area, as well as the geologic history of the continent during the Quaternary period.

The Section of Paleontology and Stratigraphy investigates and determines the relative age and equivalence of the strata in different areas, and refers the formations to a geologic time scale.

The Section of Geology of Metalliferous Deposits studies metalliferous deposits and minerals and investigates the conditions and modes of ore deposits; while the Section of Geology of Non-Metalliferous Deposits studies non-metallic deposits and minerals, exclusive of fuels. The Sections of Geology of Eastern Coal Fields and Geology of Western Coal Fields investigate coal deposits east and west of the one-hundredth meridian, respectively, and the Section of the Geology of Oil and Gas Fields makes examinations of oil and gas fields.

The Committee on Geologic Names is a standing committee organized to insure uniformity in geologic classification and nomenclature in Survey publications, to prevent unnecessary duplication of geologic names, and to reduce if possible the number of names employed. Under the instructions of the Director this committee considers all geologic names used in manuscripts prepared by members of the Geological Survey for both official and unofficial publication. The chiefs of the sections in the Division of Geology and the chief of the Division of Alaskan Mineral Resources serve as associate members of this committee and attend meetings at which matters pertaining to their respective sections or divisions are under consideration.

The Committee on Physiography, as stated in the report of the Director for the year 1916, is charged with the following duties:

1. To read critically and give advice as to physiographic papers or physiographic chapters or sections in other papers submitted for publication by the Survey.

2. To consider the classification and nomenclature of physiographic provinces.

3. To prepare or make recommendations as to the preparation of physiographic descriptions in popular language, to be printed on the backs of topographic sheets.

4. To consult with geologists regarding the solution of physiographic problems.

5. To formulate the usage of physiographic terms.

6. To confer with the chiefs of sections and with the chief geologist regarding physiographic work to be undertaken by the Geological Survey.

Division of Chemical and Physical Research. The Division of Chemical and Physical Research, under the supervision of a geologist in charge, makes such chemical and mineralogical determinations as are required by the general work of the Survey and carries on special research work in chemistry and physics. It is organized in three sections:

1. Administrative and General
2. Section of Chemistry
3. Section of Physics

Division of Mineral Resources. The Division of Mineral Resources, under the direction of a geologist in charge, makes field and office studies of mineral resources and industries and collects and compiles for publication statistical information concerning the mineral industries of the United States. It is organized in the following subdivisions:

1. Administrative and General
2. Metals Section
3. Non-Metals Section
4. Field Offices

The Metals Section and the field offices are in charge of the head of the division.

Field offices are maintained at Denver, Salt Lake City, and San Francisco. To each of these offices is assigned the collection and compilation of the metal-mine reports of a given part of the western territory. The heads of these offices act in coöperation with other members of the Survey when necessary and by keeping in close touch with the mining regions of the West they procure and disseminate much valuable information that could not readily be obtained otherwise. These offices are, therefore, general Survey headquarters and bureaus of information in their respective regions.

The reports issued by the division on the occurrence and production of the several minerals are prepared in part by members giving all their time to the division, and in part by other members of the Survey assigned for part of their time to the work. The supervision of the work remains throughout in the hands of the division.

Division of Alaskan Mineral Resources. The Division of Alaskan Mineral Resources, under the direction of a geologist in charge, investigates the mineral resources of Alaska. The work of this division includes the making of both topographic and geologic surveys and the investigation of water resources, as well as the collection and compilation of the statistics of the mineral production of Alaska.

During the fiscal year 1916-17 twelve parties were engaged in surveys and investigations in Alaska. Seven of these parties were engaged in geologic surveys, three in topographic surveys, one in topographic and geologic work combined, and one in stream gaging.

Water Resources Branch. The Water Resources Branch is administered by a chief hydraulic engineer, who reports to the Director. This branch conducts surveys of the water resources of the United States, makes field examinations of the water supplies of the public lands in relation to the several

public land laws, investigates problems of water utilization, and studies the ground water supplies of the arid public lands. In this branch are prepared for publication all the water supply papers published by the Survey.

Of the 934 permanent employees of the Survey on June 30, 1917, 102 constituted the personnel of the Water Resources Branch. The branch is organized in six divisions:

1. Administrative and General
2. Division of Surface Waters
3. Division of Ground Waters
4. Division of Water Utilization
5. Division of Enlarged and Stock-Raising Homesteads
6. Division of Quality of Water.

Division of Surface Waters. The Division of Surface Waters, under the direct supervision of a hydraulic engineer, is engaged primarily in measuring the flow of rivers. It also carries on special investigations of conditions affecting stream flow and the utilization of streams.

At selected places, known as gaging stations, measurements of discharge are made and other data are collected from which the daily flow of streams is computed. On June 30, 1917, there were 1,178 gaging stations, only 36 of which, however, were maintained by the Survey alone, all the rest being maintained in coöperation with other services of the government, with private persons, and with states and municipalities.

The work of the gaging stations, as well as all other field investigations incident to the work of the division, is supervised from district offices, of which there are 17, including one in Hawaii. Data collected from the district offices are transmitted to the Washington office, where they are reviewed in the computing section and prepared for publication. This review insures accuracy in the data and brings the results from different parts of the country to a uniform stand-

ard. Regular field inspections are made, and through annual conferences of the district engineers the work in the several districts is further standardized.

Division of Ground Waters. The Division of Ground Waters, under the administration of a geologist, makes surveys of waters occurring below the surface of the ground with reference to their utilization. It undertakes the study of conditions controlling the quality and quantity of underground waters, and of methods of recovering and utilizing such waters. Most of the members of the division are geologists and close coöperation exists with the Geologic Branch.

Division of Water Utilization. The Division of Water Utilization is under the direct administrative control of the chief of the branch. It makes all field examinations necessary for the classification of the public lands with respect to their water resources, except as to their suitability for designation as enlarged or stock-raising homesteads. It makes all field examinations incident to the report to the Secretary by the Survey on applications for rights of way over the public lands, for power development, irrigation, or municipal water supply.

Division of Enlarged and Stock-Raising Homesteads. The Division of Enlarged and Stock-Raising Homesteads is under the direct supervision of the chief of the branch. Its work embraces the examination of public lands thought suitable for designation as open to entry under the enlarged homestead or stock-raising homestead laws.

Division of Quality of Water. The Division of Quality of Water is under the direct administration of a chemist. It investigates the mineral quality of surface and ground waters and analyzes the samples of water collected by the field forces of other divisions.

Land Classification Board. The function of the Land Classification Board is to classify and evaluate the public

lands under the public land laws, and to give opinion on applications for entry or right of way on such lands.

In 1908, in consequence of the growth of the Survey's land classification work in volume and importance, the Land Classification Board was organized as a section of the Geologic Branch. Upon this board was laid the duty of systematizing that work more completely and of adopting certain definite principles that might be consistently, uniformly and thoroughly applied to it. On May 1, 1912, the importance of the classification work was further recognized by the designation of the Land Classification Board as a separate branch of the Survey, coördinate in rank with the Geologic, Topographic and Water Resources Branches.

The board maintains no field staff of its own, but bases its reports on the results of field and laboratory investigations made by other branches of the Survey or by the General Land Office.

The board is in charge of a geologist. It is composed of three divisions, as follows:

1. Administrative and General
2. Division of Mineral Classification
3. Division of Hydrographic Classification

Of the 934 permanent employees of the Survey on June 30, 1917, 42 constituted the personnel of the Land Classification Board.

Division of Mineral Classification. The Division of Mineral Classification is divided into four sections—coal, oil, phosphate and metalliferous—a committee, with a chairman in charge, being organized for each section. The chief of the division, who is directly responsible to the chief of the branch, is also the geologist in charge of the Metalliferous Section.

Division of Hydrographic Classification. The Division of Hydrographic Classification is composed of the Section of Utilization, the chairman of which is a hydraulic engineer,

and the Section of Classification, the chairman of which is a geologist. As indicated by its title, this division classifies public lands with relation to their water resources.

Publication Branch. The Publication Branch edits, prepares for printing and engraving, and reads the proof of all publications—including text, maps and illustrations—issued by the Survey. It operates the Survey's engraving and printing plant and distributes all the publications of the Survey. It also develops, prints and prepares either for publication or for filing all photographs taken by members of the Survey.

The branch is organized in four divisions, each in charge of a chief who reports directly to the Director, namely:

1. Division of Book Publication
2. Division of Map Editing
3. Division of Engraving and Printing
4. Division of Distribution

Of the 934 permanent employees of the Survey on June 30, 1917, 174 constituted the personnel of the Publication Branch.

Division of Book Publication. The Division of Book Publication, in charge of an editor, includes the section of texts, in which all manuscripts are edited and all proofs are read, and the section of illustrations, in which drawings and engravings used to illustrate official publications are prepared for this purpose.

Division of Map Editing. The Division of Map Editing is charged with the maintenance of the accepted Survey standard in all maps, geologic and topographic, issued by the Survey. It includes a section of geologic maps and a section of topographic maps. These sections are regarded as a part of the Publication Branch, but their work is so intimately associated with the work performed in the Geologic and Topographic Branches that they are in fact administered as parts of those branches.

Division of Engraving and Printing. The Division of Engraving and Printing, administered by the chief engraver, is charged with all mechanical work involved in the reproduction of official maps or other illustrations published directly by the Survey. It includes an engraving and printing plant, an instrument shop and a photographic laboratory. It has been organized on a scale that permits it not only to do the work of this character required by the Survey but also to obtain from the Public Printer, by bidding in competition with private firms, work for other branches of the government.

Plant. The headquarters of the United States Geological Survey are in the Interior Department building, on the block bounded by E and F and 18th and 19th Streets, N. W., at Washington.

The chemical laboratory, in which is performed the analytical work necessary for the completion of geologic field investigations and some other researches in chemical geology, has equipment valued at \$22,000. The equipment in the physical laboratory is valued at \$5,000. The equipment used in the engraving and printing plant is valued at over \$1,000,000. This equipment includes 10 power presses and 13 hand presses. The library contains about 120,000 volumes, 100,000 pamphlets and 25,000 maps.

The Survey maintains branch offices at Denver, Salt Lake City, San Francisco and other places, most of them in government buildings.

APPENDIX I

OUTLINE OF ORGANIZATION

EXPLANATORY NOTE

The Outlines of Organization have for their purpose to make known in detail the organization and personnel possessed by the several services of the national government to which they relate. They have been prepared in accordance with the plan followed by the President's Commission on Economy and Efficiency in the preparation of its outlines of the organization of the United States government.¹ They differ from those outlines, however, in that while the commission's report showed only organization units, the presentation herein has been carried far enough to show the personnel embraced in each organization unit.

These outlines are of value not merely as an effective means of making known the organization of the several services. If kept revised to date by the services they constitute exceedingly important tools of administration. They permit the directing personnel to see at a glance the organization and personnel at their disposition. They establish definitely the line of administrative authority and enable each employee to know his place in the system. They furnish the *essential basis* for making plans for determining costs by organization division and subdivision. They afford the data for a consideration of the problem of classifying and standardizing personnel and compensation. Collectively, they make it possible to determine the number and location of organization divisions of any particular kind, as for example—laboratories, libraries, blueprint rooms, or any other kind of plant possessed by the na-

¹ House Doc. 458, 62d Cong., 2d Sess. 1912—2 vols.

tional government, to what services they are attached and where they are located, or to determine what services are maintaining stations at any city or point in the United States.

As regards individual positions, changes are of course constantly taking place, both as to character and compensation. This is of course especially true at the present time, owing to the abnormal conditions resulting from the war.

OUTLINE OF ORGANIZATION
U. S. GEOLOGICAL SURVEY
DEPARTMENT OF THE INTERIOR

March 1, 1917¹

	NUMBER	SALARY RATE
1. General Administrative Branch		
1. Office proper of the Director		
Director	1	\$6,000.00
Private Secretary to the Director	1	1,740.00
Clerk	1	1,600.00
Messenger	1	840.00
2. Office of Chief Clerk		
1. Office proper of Chief Clerk		
Chief Clerk	1	2,500.00
Messenger	1	600.00
2. Executive Division		
1. Office of Chief of Executive Division		
Chief of Executive Division	1	2,400.00
Junior Clerk	1	1,200.00
Messenger	1	480.00
2. Mails, records and files		
Clerk	1	1,620.00
"	1	1,560.00
Junior Clerk	1	1,440.00
"	1	1,200.00
Under Clerk	1	1,080.00
"	1	1,020.00
"	1	1,000.00
"	1	900.00
Copyist	1	720.00
3. Appointments		
Clerk	1	1,740.00
Under Clerk	1	1,140.00
Skilled Laborer	1	960.00

¹The personnel of the several units is being constantly changed. As occasion demands, employees are transferred from one division to another.

	NUMBER	SALARY RATE
1. General Administrative Branch.— <i>Cont.</i>		
2. Office of Chief Clerk.— <i>Cont.</i>		
2. Executive Division.— <i>Cont.</i>		
4. Multigraph Room		
Clerk	1	\$1,620.00
Skilled Laborer	1	1,200.00
Assistant Map Printer	1	900.00
Messenger	1	780.00
"	2	540.00
Apprentice	1	420.00
" (per diem)	1	1.25
3. Office of Chief Disbursing Clerk		
Chief Disbursing Clerk	1	2,500.00
Cashier	1	2,400.00
Junior Clerk	1	1,400.00
4. Division of Accounts		
Senior Clerk	1	1,920.00
Accountant	1	1,800.00
Clerk	2	1,680.00
"	1	1,560.00
Junior Clerk	1	1,380.00
" "	1	1,320.00
" "	1	1,200.00
Under Clerk	1	1,080.00
" "	2	1,020.00
Messenger	1	720.00
"	1	480.00
" (per diem)	1	1.50
Assistant Map Printer (per diem)	1	1.25
5. Library Division		
Librarian	1	2,000.00
Assistant Librarian	1	1,680.00
Cataloguer	1	1,380.00
Stenographer and Typewriter	1	1,020.00
Skilled Laborer	1	1,020.00
Clerk	1	1,000.00
Laborer	1	900.00
6. Engineer, Messengers and Labor Force		
1. Engineer Force		
Assistant Electrical Engineer	1	1,800.00
Engineer	1	1,200.00
Expert Mechanic	1	1,200.00
Wireman	1	1,020.00
Plumber and Steamfitter	1	840.00
Firemen	2	720.00
2. Carpenter Force		
Carpenter and Cabinet-Maker	1	1,200.00
Carpenter	1	900.00
Cabinet-Maker	1	900.00
3. Labor Force		
Laborer	1	780.00

	NUMBER	SALARY RATE
1. General Administrative Branch.— <i>Cont.</i>		
6. Engineer, Messengers and Labor Force.— <i>Cont.</i>		
3. Labor Force.— <i>Cont.</i>		
Laborer	1	\$720.00
"	3	660.00
"	1	600.00
"	1	540.00
"	10	480.00
"	2	420.00
" (per month)	1	40.00
Janitor	1	600.00
Charwoman	1	270.00
" (per diem)	1	.....
4. Watch Force		
Lieutenant of the Watch	1	1,020.00
" " " "	2	840.00
Watchman	1	840.00
"	6	720.00
5. Messenger Force		
Messenger	1	840.00
"	2	420.00
"	6	360.00
Assistant Map Printer	1	360.00
" " " (per diem)	1	1.25
" " " (per diem)	6	1.00
Apprentice (per diem)	2	1.25
2. Topographic Branch		
1. Administrative and General		
Chief Geographer	1	4,000.00
Geographers (Computing)	2	3,000.00
" (Inspector)	1	2,500.00
Clerks	2	1,740.00
"	3	1,560.00
Junior Clerk	1	1,440.00
" "	1	1,200.00
Under Clerk	1	1,140.00
" "	1	1,020.00
" "	2	960.00
" "	1	840.00
Topographic Engineers (Computing)	3	2,520.00
" " (Computing)	1	2,340.00
" " (Compiling guidebooks)	1	2,340.00
" "	1	2,160.00
Topographer (Computing)	1	2,000.00
"	1	1,800.00
Assistant Topographer	1	1,740.00
" " (Inspector)	1	1,620.00
Draftsman	1	2,520.00
"	1	1,800.00

	NUMBER	SALARY RATE
2. Topographic Branch.— <i>Cont.</i>		
1. Administrative and General.— <i>Cont.</i>		
Draftsman	1	\$1,620.00
Topographic Draftsman	2	1,500.00
“ “	2	1,380.00
Skilled Mechanician	1	1,260.00
Laborer	1	780.00
2. Atlantic Division		
Geographer	1	3,600.00
Topographic Engineer	1	2,520.00
“ “	1	2,460.00
“ “	2	2,340.00
“ “	3	2,280.00
“ “	2	2,160.00
“ “	2	2,000.00
“ “	2	1,920.00
Topographer	1	2,000.00
“	1	1,800.00
“	1	1,740.00
Assistant Topographer	1	1,740.00
“ “	3	1,620.00
“ “ (per month)	1	145.00
“ “ (per month)	2	135.00
“ “ (per month)	1	115.00
“ “ (per month)	6	100.00
Junior Topographer	1	85.00
“ “ (per month)	1	75.00
“ “ (per month)	3	70.00
3. Central Division		
Geographer	1	3,600.00
Topographic Engineer	1	3,000.00
“ “	1	2,280.00
“ “	3	2,160.00
“ “	4	1,920.00
Topographers	2	1,800.00
Assistant Topographer	1	1,380.00
“ “ (per month)	1	145.00
“ “ (per month)	2	135.00
“ “ (per month)	2	125.00
“ “ (per month)	1	100.00
Junior Topographers	4	85.00
“ “ (per month)	1	80.00
“ “ (per month)	3	75.00
“ “ (per month)	2	65.00
4. Rocky Mountain Division		
Geographer	1	2,700.00
Topographic Engineer	1	2,280.00
“ “	1	1,980.00
“ “	1	1,920.00
“ “ (per month)	1	180.00
“ “ (per month)	1	165.00

	NUMBER	SALARY RATE
2. Topographic Branch.— <i>Cont.</i>		
4. Rocky Mountain Division.— <i>Cont.</i>		
Topographer	1	\$1,800.00
Assistant Topographer	1	1,740.00
“ “ (per month)	1	1,620.00
“ “ (per month)	3	135.00
“ “ (per month)	3	125.00
“ “ (per month)	2	115.00
“ “ (per month)	4	100.00
Junior Topographers (per month)	3	85.00
“ “ (per month)	2	75.00
5. Northwestern Division		
Geographer	1	3,600.00
Topographic Engineer	1	1,980.00
Topographers	2	1,800.00
Assistant Topographer	1	1,800.00
Junior Topographer (per month)	1	90.00
6. Pacific Division		
Geographer	1	3,300.00
Topographic Engineer	1	2,700.00
“ “ (per month)	1	2,160.00
Topographers (per month)	1	180.00
“ “ (per month)	2	1,800.00
Assistant Topographer (per month)	2	150.00
“ “ (per month)	1	1,740.00
“ “ (per month)	1	135.00
“ “ (per month)	3	115.00
“ “ (per month)	3	100.00
Junior Topographer (per month)	1	85.00
“ “ (per month)	1	65.00
7. Division of Military Surveys		
Topographic Engineer	1	2,700.00

In addition to the above, the following (belonging to the Topographic Branch) are on furlough or temporarily with other Services:

Junior Topographer (Michigan State Highway Commission)		
(per month)	1	80.00
Junior Topographer (Coast and Geodetic Survey)		
(per month)	1	75.00
Topographer (Alaskan Engineering Commission)		
(per diem)	1	5.00
Topographic Engineer (furlough)		
(per diem)	1	7.50
Junior Topographic (furlough)		
(per month)	1	85.00
“ “ (furlough)		
(per month)	1	80.00
“ “ (furlough)		
(per month)	1	70.00

NUMBER SALARY RATE

3. Geologic Branch

1. Division of Geology

1. Administrative and General

Chief Geologist (Part of time in
Section of the Geology of Oil
and Gas Fields)

I \$4,500.00

Geologists (per diem) 2 13.00

Senior Clerks 2 1,980.00

" " 1 1,920.00

Geologic Draftsman { Employed in 1 1,800.00

Draftsman { this Section, 1 1,740.00

Topographic { but belong- 1 1,680.00

Draftsman { ing under 1 1,680.00

Copy. Topographic { Section of 1 1,200.00

Draftsman { illustrations 1 1,200.00

Apprentice { under the 1 1,000.00

Draftsman { Publication 1 1,000.00

Copyist { Branch) 1 720.00

Clerks 6 1,500.00

" 2 1,200.00

" (per diem) 1 4.00

Junior Clerk 1 1,500.00

" " 1 1,440.00

" " 3 1,320.00

" " 3 1,200.00

" " 1 1,140.00

" " (per diem) 1 4.75

Under Clerks 2 1,080.00

" " 2 1,020.00

" " 2 900.00

Library Assistant 1 1,320.00

Skilled Laborer (Prep. of Rock

Specialist) 1 720.00

Apprentice 1 480.00

2. Section of Eastern Areal Geology

Geologist (Chief of Section) 1 4,000.00

" (Part of time only.

Chief of Section of Geologic

Map Editing under Publica-

tion Branch) 1 3,000.00

Geologists 2 2,400.00

" 1 2,280.00

" (per diem) 2 7.00

Associate Geologist 1 1,980.00

" " 1 1,860.00

Geologic Aid (per diem) 1 4.00

3. Section of Western Areal Geology

Geologist (Chief of Section) 1 2,700.00

" 2 2,700.00

" 1 2,280.00

" (per diem) 1 12.00

	NUMBER	SALARY RATE
3. Geologic Branch.— <i>Cont.</i>		
1. Division of Geology.— <i>Cont.</i>		
3. Section of Western Areal Geology.— <i>Cont.</i>		
Geologist (per diem)	I	\$ 7.00
Associate Geologist	I	2,160.00
"	I	1,740.00
4. Section of Coastal Plain Investigations		
Geologist (Chief of Section; part time in Section of Paleontology and Stratigraphy)	I	3,300.00
Geologist (Part time in Section of the Geology of Oil and Gas Fields)	I	3,000.00
Geologist	I	2,700.00
Associate Geologist	I	1,620.00
" (Part time in Section of Paleontology and Stratigraphy)	I	1,620.00
Assistant Geologist (Part time in Section of Paleontology and Stratigraphy) (per diem)	I	6.50
5. Section of Glacial Geology		
Geologist (Chief of Section)	I	2,700.00
"	I	2,700.00
6. Section of Paleontology and Stratigraphy		
Geologist (Chief of Section)	I	3,600.00
" (See under Section of Coastal Plain Investigations)	I	.....
Geologist	I	3,000.00
"	2	2,880.00
Associate Geologist { See under Section of Coastal Plain Investigations }	I	.....
Assistant Geologist { }	I	.....
Geologist and Paleontologist	I	2,400.00
Paleontologist	I	2,000.00
Preparator of Fossils	I	1,500.00
" " "	I	1,380.00
" " "	I	1,260.00
" " "	I	1,140.00
" " "	I	1,020.00
Preparator (per hour)	I	.20
7. Section of the Geology of Metalliferous Deposits		
Geologist (Chief of Section)	I	4,500.00
"	2	3,300.00
" (Part time in Division of Mineral Resources)	4	3,300.00
Geologists	2	3,000.00
" (In Charge of Subsec-		

NUMBER SALARY RATE

3. Geologic Branch.—*Cont.*I. Division of Geology.—*Cont.*7. Section of the Geology of Metalliferous Deposits.—*Cont.*tion of Investigations in
Petrology)

	I	\$2,700.00
Geologist	I	2,700.00
"	I	2,400.00
"	I	2,220.00

Associate Geologist (Part time in
Division of Mineral Re-
sources)

	I	2,160.00
Associate Geologist	I	1,740.00
Assistant Geologist	I	2,100.00

8. Section of the Geology of Non-metalliferous Deposits

Geologist (Chief of Section)	I	3,300.00
"	I	3,000.00
"	I	2,700.00
" (per diem)	I	7.00
Associate Geologist	I	2,160.00
"	I	2,100.00

9. Section of the Geology of Eastern Coal Fields

Geologist (Chief of Section)	I	4,000.00
"	I	2,700.00
Geologic Aid (per month)	I	75.00

10. Section of the Geology of Western Coal Fields

Geologist (Chief of Section)	I	4,000.00
"	I	2,700.00
" (per diem)	I	7.00
Associate Geologist	I	2,100.00
Assistant Geologist	I	1,380.00
"	I	1,320.00

11. Section of the Geology of Oil and Gas Fields

Chief Geologist (Chief of Section) (See under Administrative and General Section)	I	.....
Geologist (See under Section of Coastal Plain Investigation)	I	.....
Geologist	I	3,000.00
"	I	2,580.00
"	2	2,220.00
"	I	2,160.00
Associate Geologist	I	2,100.00
"	4	1,980.00
"	I	1,960.00
"	I	1,860.00
"	I	1,740.00

	NUMBER	SALARY RATE
3. <i>Geologic Branch.—Cont.</i>		
1. Division of Geology.— <i>Cont.</i>		
11. Section of the Geology of Oil and Gas Fields.— <i>Cont.</i>		
Associate Geologist	1	\$1,680.00
Assistant Geologist	1	1,500.00
“ “	1	1,320.00
Paleontologist	1	2,000.00
2. Division of Chemical and Physical Research		
1. Administrative and General		
Geologist (Chief of Division)	1	4,000.00
Junior Clerk	1	1,320.00
Skilled Laborer	1	1,080.00
Apprentice	1	420.00
2. Section of Chemistry		
Chemist	1	3,000.00
“	1	2,700.00
“	1	2,400.00
Assistant Chemists	2	1,980.00
“ “	1	1,560.00
Junior Chemist	1	1,320.00
Machinist (per diem)	1	3.75
3. Section of Physics		
Physical Chemist	1	2,700.00
Physical Geologist	1	2,580.00
Assistant Physical Geologist	1	1,620.00
3. Division of Mineral Resources		
1. Administrative and General		
Geologist (Chief of Division)	1	3,600.00
Statistician	1	2,100.00
Statistical Experts	2	1,440.00
Assistant Statistician	1	1,440.00
Clerk	1	1,400.00
Junior Clerks	6	1,440.00
“ “	1	1,380.00
“ “	2	1,260.00
“ “	2	1,200.00
Under Clerks	2	1,140.00
“ “	4	1,080.00
“ “	1	1,020.00
“ “	3	960.00
“ “	1	900.00
Skilled Laborer	1	1,200.00
Copyist	1	840.00
Messenger	1	480.00
2. Section of Metalliferous Deposits		
Geologists { See under Section of the Geology of Met-	4	.....
Associate } alliferous Deposits,		
Geologist { Division of Geology. }	1	.....

	NUMBER	SALARY RATE
3. Geologic Branch.— <i>Cont.</i>		
3. Division of Mineral Resources.— <i>Cont.</i>		
3. Section of Non-metalliferous Deposits		
Geologists	2	\$2,400.00
4. Field Offices (Denver, Salt Lake City and San Francisco)		
Statistician	1	3,000.00
"	1	2,700.00
"	1	2,400.00
"	1	2,280.00
"	1	1,740.00
Junior Clerk	1	1,380.00
Under Clerk	1	900.00
" " (per diem)	1	3.50
4. Division of Alaskan Mineral Resources		
1. Administrative and General		
Chief Geologist (Chief of Division)	1	4,500.00
Senior Clerk	1	1,980.00
Clerk	1	1,560.00
Under Clerk	1	1,020.00
2. Technical Investigations and Mapping		
Geologist and Administrative Assistant (Acts as Director in latter's absence)	1	3,600.00
Geologist	1	3,000.00
"	1	2,700.00
"	2	2,400.00
Associate Geologists	5	1,980.00
Assistant Geologist	1	1,340.00
"	1	1,200.00
Topographic Engineer	1	3,000.00
" "	2	2,340.00
" "	1	2,100.00

In addition to the above, the following are employed occasionally by the Geologic Branch:

Geologist	(per diem)	1	\$10.00
"	(per diem)	1	8.00
"	(per diem)	11	7.00
Associate Geologist	(per diem)	1	6.00
Assistant Geologists	(per annum)	2	1,200.00
" "	(per month)	1	100.00
" "	(per diem)	1	7.00
" "	(per diem)	6	6.00
" "	(per diem)	7	5.00
" "	(per diem)	1	4.50
" "	(per diem)	1	4.10
" "	(per diem)	2	4.00
Geologic Aids	(per month)	3	90.00
" "	(per month)	2	85.00

NUMBER SALARY RATE

3. Geologic Branch.—*Cont.*

4. Division of Alaskan Mineral Resources.—*Cont.*

2. Technical Investigations and Mapping.—*Cont.*

Geologic Aids	(per month)	4	\$80.00
" "	(per month)	2	75.00
" "	(per month)	1	65.00
" "	(per diem)	1	4.00
" "	(per diem)	1	3.50
Junior Geologist	(per month)	1	75.00
" "	(per diem)	2	4.00
" "	(per diem)	3	3.50
Geologist and Paleontologist			
" " "	(per diem)	1	13.00
" " "	(per diem)	1	7.00
Assistant Topographer	(per diem)	1	4.00
Clerk	(per diem)	1	5.00
Stenographer	(per hour)	1	.50
" "	(per hour)	1	.40

Standing Committees of the Geologic Branch:—

1. Committee on Geologic Names

a. Chairman (Geologist—Chief of Section of Paleontology and Stratigraphy under Division Geology)

b. Members

1. Geologist (Chief of Section of Geologic Map Editing under Publication Branch)
2. Geologist (In Section of Western Areal Geology under Division of Geology)
3. Geologist (Chief of Section of Western Areal Geology under Division of Geology)
4. Geologist (In Section of Coast Plain Investigations under Division of Geology)

c. Associate Members

1. Chiefs of Section in Division of Geology
2. Chief of Division of Alaskan Mineral Resources

2. Committee on Physiography

a. Chairman (Geologist—Chief of Section of the Geology of Western Coal Fields under the Division of Geology)

b. Members

1. Geologist (Water Resources Branch)
2. Geologist (In Section of Western Areal Geology under Division of Geology)
3. Geologist (In Section of the Geology of Oil and Gas Fields under Division of Geology)
4. Geologist and Administrative Assistant (In Division of Alaskan Mineral Resources).

4. Water Resources Branch

1. Administrative and General

Chief Hydraulic Engineer (Chief of Branch—also in charge of Division of Water Utilization)

I

\$4,000.00

	NUMBER	SALARY RATE
4. Water Resources Branch— <i>Cont.</i>		
1. Administrative and General.— <i>Cont.</i>		
Senior Clerk	I	\$1,920.00
Junior Clerk (Part time in Division of Ground Waters)	I	1,320.00
Under Clerk	I	1,080.00
Copyist	I	720.00
Messenger	I	480.00
2. Division of Surface Waters		
1. Middle Atlantic District (Office, Washington, D. C.)		
Hydraulic Engineer (In Charge of Division)	I	3,600.00
Engineer	I	2,160.00
Assistant Engineer	I	1,920.00
" "	2	1,620.00
Junior Engineer	I	1,440.00
" "	I	1,320.00
Senior Clerk (per diem)	I	6.00
Junior Clerk	I	1,320.00
Under Clerk	I	720.00
Stenographic Clerk (per diem)	I	3.00
2. New England District (Office: Bos- ton, Mass.)		
Engineer	I	2,160.00
Junior Engineer	I	1,200.00
Under Clerk	I	900.00
3. New York District (Office: Albany, N. Y.)		
Hydraulic Engineer	I	3,000.00
Assistant Engineer	I	1,800.00
Junior Engineer	I	1,320.00
" "	I	1,200.00
Under Clerk	I	1,080.00
4. South Atlantic and Eastern Gulf District (Office: Atlanta, Ga.)		
Assistant Engineer	I	2,100.00
Under Clerk	I	900.00
5. Texas District (Austin, Texas)		
Engineer	I	2,160.00
Under Clerk	I	900.00
6. Ohio Valley District (Office: Tem- porarily at Washington, D. C.)		
Hydraulic Engineer	I	3,000.00
Assistant Engineer	I	1,740.00
Under Clerk	I	840.00
7. Upper Mississippi Valley and Great Lakes District. (Office: Madi- son, Wis.; Sub-Office: St. Paul, Minn.)		
Hydraulic Engineer (per diem)	I	8.00

NUMBER SALARY RATE

4. Water Resources Branch— <i>Cont.</i>		
2. Division of Surface Waters.— <i>Cont.</i>		
7. Upper Mississippi Valley and Great Lakes District. (Office: Madison, Wis.; Sub-Office: St. Paul, Minn.)— <i>Cont.</i>		
Assistant Engineer	I	\$2,100.00
“ “	I	1,500.00
Junior Engineer	I	1,200.00
“ “	I	1,080.00
“ “ (per diem)	I	4.00
8. Upper Missouri District (Office: Helena, Mont.)		
Hydraulic Engineer	I	2,280.00
Assistant Engineer	I	1,620.00
“ “ (per diem)	I	7.00
Junior Engineer	I	1,320.00
Clerk	I	900.00
9. Rocky Mountain District (Office: Denver, Colo.)		
Hydraulic Engineer	I	3,000.00
Junior Engineer	I	1,320.00
“ “	I	1,200.00
“ “	I	1,080.00
“ “ (per diem)	I	5.00
Under Clerk	I	1,140.00
10. Idaho District (Office: Boise, Idaho)		
Assistant Engineer	I	2,100.00
Junior Engineer	I	1,200.00
Under Clerk	I	1,140.00
11. Great Basin District (Office: Salt Lake City, Utah)		
Assistant Engineer	I	1,860.00
“ “	I	1,740.00
Junior Engineer	I	1,380.00
“ “	I	1,320.00
Under Clerk	I	960.00
12. Washington District (Office: Tacoma, Wash.)		
Engineer	I	2,160.00
Junior Engineer	I	1,500.00
“ “	I	1,440.00
“ “ (per diem)	I	4.00
Under Clerk	I	900.00
13. Oregon District (Office: Portland, Oregon)		
Hydraulic Engineer	I	2,700.00
Junior Engineer	I	1,440.00
“ “	I	1,080.00
Junior Clerk	I	1,200.00

NUMBER SALARY RATE

4. Water Resources Branch—*Cont.*2. Division of Surface Waters.—*Cont.*

14. California District (Office: San Francisco, Cal.; Sub-Office: Los Angeles, Cal.)

Hydraulic Engineer	I	\$2,700.00
Assistant Engineer	I	1,860.00
" "	I	1,500.00
" "	I	1,440.00
Junior Engineer	I	1,320.00
" "	2	1,080.00
Junior Clerk	I	1,320.00
Under Clerk (per diem)	I	3.25

15. Arizona District (Phoenix, Ariz.)

Assistant Engineer	I	2,160.00
Junior Engineer	I	1,200.00
Under Clerk	I	900.00

16. Hawaiian District (Office: Honolulu, Hawaii)

Hydraulic Engineer (Paid by Hawaii; nominal Salary of \$12 per annum paid by U. S.)	I	12.00
Assistant Engineers	2	1,800.00
Junior Engineer	I	1,500.00

3. Division of Ground Waters

Geologist (Chief of Division)	I	2,580.00
Geologist	I	2,400.00
Associate Engineer	I	1,680.00
Assistant Chemist	I	1,620.00
Assistant Geologist	I	1,500.00
" "	I	1,320.00
" "	I	1,200.00
Geologic Aid (per diem)	I	3.25
Junior Clerk	I	1,200.00

" " (See under Administrative and General)

I

4. Division of Water Utilization

Chief Hydraulic Engineer (See under Administrative and General)

Hydraulic Engineer	I	2,880.00
" "	I	2,700.00
Junior Engineer	I	1,200.00
Junior Clerk	I	1,200.00
Draftsman (per hour)	I	.50
Stenographer (per hour)	I	.40

In addition to the above the following have been temporarily assigned to the Division of Alaskan Mineral Resources under the Geologic Branch, or are unassigned:

OUTLINE OF ORGANIZATION

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	NUMBER	SALARY RATE
4. Water Resources Branch— <i>Cont.</i>		
4. Division of Water Utilization.— <i>Cont.</i>		
Assistant Engineer (Alaskan Mineral Resources)	1	\$1,800.00
Assistant Engineer (Alaskan Mineral Resources)	1	1,620.00
Assistant Engineer (Unassigned) (per diem)	1	7.00
5. Land Classification Board		
1. Administrative and General		
Geologist (Chief of Branch)	1	\$4,000.00
Senior Clerk	1	1,800.00
Junior Clerks	1	1,320.00
“ “	1	1,260.00
“ “	2	1,200.00
“ “ (per diem)	1	5.00
Under Clerk	3	1,140.00
“ “	3	1,080.00
“ “	1	1,020.00
“ “	1	900.00
“ “	2	840.00
“ “	1	780.00
Draftsman	1	1,560.00
Copy. Topographic Draftsman	1	1,260.00
“ “	1	1,200.00
Skilled Laborer	1	540.00
Laborer	1	900.00
Messenger	1	600.00
“	1	480.00
2. Division of Mineral Classification		
1. Coal Section		
Junior Topographer	1	1,140.00
2. Oil Section		
Assistant Geologist	1	1,500.00
3. Phosphate Section		
Associate Geologist	1	1,800.00
4. Metalliferous Section		
Geologist (Chief of Division)	1	2,700.00
3. Division of Hydrographic Classification		
1. Section of Utilization		
Hydraulic Engineer (Chairman of Section)	1	3,000.00
Assistant Engineer	1	1,860.00
“ “	1	1,620.00
2. Section of Classification		
Geologist (Chairman of Section)	1	2,700.00
Assistant Classifier	1	1,440.00
Junior Engineers	2	1,380.00
Junior Topographer	1	1,020.00

	NUMBER	SALARY RATE
6. Publication Branch		
1. Division of Book Publication		
1. Texts Section		
Editor	1	\$2,400.00
Assistant Editor	1	2,400.00
Senior Clerk	1	1,800.00
Copy Editor	1	1,740.00
Editorial Clerk	1	1,800.00
" "	1	1,560.00
" "	1	1,440.00
" " (per diem)	1	5.00
Assistant Map Printer	1	360.00
2. Illustrations Section		
Draftsman	1	2,400.00
"	1	1,920.00
"	2	1,740.00
Paleontologist Draftsman	1	1,800.00
" "	1	1,560.00
" "	1	1,500.00
" "	1	1,200.00
Artist Draftsman	1	1,200.00
Copy Topographic Draftsman	1	960.00
Clerk	1	900.00
Copyist	1	720.00
Messenger	1	480.00
3. Distribution Section		
Senior Clerk	1	2,100.00
Clerk	1	2,000.00
"	1	1,740.00
"	1	1,200.00
"	2	900.00
Junior Clerk	1	1,200.00
Under Clerk	1	1,140.00
" "	1	1,080.00
" "	1	1,000.00
" "	1	960.00
" "	3	900.00
" "	1	840.00
Skilled Laborer	1	960.00
" "	2	840.00
Laborer	1	960.00
"	1	600.00
Messengers	3	540.00
2. Division of Map Editing		
1. Section of Geologic Maps		
Editor (paid by Geologic Branch)	1	.....
Map Reviser	1	1,620.00
Geologic Draftsman	1	1,980.00
Clerk	1	1,620.00
2. Section of Topographic Maps		
Editor	1	2,520.00

	NUMBER	SALARY RATE
6. Publication Branch.—Cont.		
2. Division of Map Editing.—Cont.		
2. Section of Topographic Maps.—Cont.		
Map Reviser	1	\$1,620.00
"	1	1,440.00
Topographic Draftsman	1	1,740.00
Clerk	1	1,620.00
3. Division of Engraving and Printing		
1. Engraving and Printing Section		
Chief Engraver	1	4,000.00
Senior Clerk	1	1,920.00
Under Clerk	1	1,080.00
Cartographic Specialist	1	1,620.00
Engraver	1	2,100.00
"	1	1,740.00
"	1	1,620.00
Copper-plate Map Engraver	2	1,920.00
" " "	1	1,800.00
" " "	1	1,620.00
" " "	3	1,560.00
" " "	2	1,440.00
" " "	1	1,400.00
" " "	1	1,260.00
" " "	5	1,200.00
Assistant Engravers	2	780.00
Assistant Map Engravers	4	720.00
" " "	3	660.00
Apprentice Engravers	2	660.00
Lithographic Map Engraver	1	2,100.00
" " "	2	1,680.00
" " "	1	1,500.00
" " "	2	1,260.00
" " "	1	720.00
Draftsman	1	1,200.00
Photolithographer	1	1,200.00
Wet-plate Photographer	1	1,380.00
Negative Cutter	2	1,200.00
" " "	1	1,140.00
" " "	1	1,020.00
" " "	1	780.00
" " "	1	720.00
Negative Cutter and Lithographic		
Draftsman	1	780.00
Printers	2	1,440.00
Map Printer	1	1,800.00
" " "	1	1,620.00
" " "	1	1,500.00
" " "	2	1,320.00
" " "	1	1,320.00
" " "	2	1,260.00
" " "	1	1,200.00

	NUMBER	SALARY RATE
6. Publication Branch.— <i>Cont.</i>		
3. Division of Engraving and Printing.— <i>Cont.</i>		
1. Engraving and Printing Section.— <i>Cont.</i>		
Map Printer	1	\$1,020.00
“ “	1	960.00
“ “ (per diem)	1	4.00
Assistant Map Printers	2	1,140.00
“ “ “	1	1,100.00
“ “ “	2	1,080.00
“ “ “	2	900.00
“ “ “	1	840.00
“ “ “	1	780.00
“ “ “	1	720.00
“ “ “	1	660.00
“ “ “ (per diem)	5	2.00
“ “ “ (per diem)	3	1.75
“ “ “ (per diem)	6	1.50
“ “ “ (per diem)	3	1.25
“ “ “ (per diem)	7	1.00
Laborer	2	720.00
“	2	660.00
“	1	600.00
“	1	540.00
“ (per diem)	1	1.50
Messenger	1	540.00
2. Instrument Shop		
Expert Mechanician	1	2,700.00
Skilled Laborer	1	720.00
“ “	1	660.00
3. Photographic Laboratory		
Photographers	2	2,000.00
Assistant Photographers	2	1,620.00
“ “	1	1,320.00
“ “	2	1,200.00
“ “	1	900.00
“ “	1	720.00

APPENDIX 2

CLASSIFICATION OF ACTIVITIES

EXPLANATORY NOTE

The Classifications of Activities have for their purpose to list and classify in all practicable detail the specific activities engaged in by the several services of the national government. Such statements are of value from a number of stand-points. They furnish, in the first place, the most effective showing that can be made in brief compass of the character of work performed by the service to which they relate. Secondly, they lay the basis for a system of accounting and reporting that will permit of the showing of total expenditures classified according to activities. Finally, taken collectively, they make possible the preparation of a general or consolidated statement of the activities of the government as a whole. Such a statement will reveal in detail, not only what the government is doing, but the services in which the work is being performed. For example, one class of activities that would probably appear in such a classification is that of "scientific research." A subhead under this class would be "chemical research." Under this head would appear the specific lines of investigation under way and the services in which they were being prosecuted. It is hardly necessary to point out the value of such information in planning for future work and in considering the problem of the better distribution and co-ordination of the work of the government. The Institute has it in contemplation to attempt such a general listing and classification of the activities of the government upon the completion of the present series.

CLASSIFICATION OF ACTIVITIES

1. Topographic Survey
2. Geologic Survey
3. Investigation of Mineral Resources
 1. Metalliferous Deposits
 2. Non-metalliferous Deposits
 3. Coal
 4. Oil and gas
4. Investigation of Water Resources
5. Classification of Public Lands
6. Compilation of Statistics
 1. Mineral Resources
 2. Production of Mines and Quarries
 3. Imports and Exports
7. Scientific Research
 1. Chemical
 2. Physical
 3. Geological
 4. Methods of Flood Prevention and Drainage
 5. Stream Pollution and Remedial Methods
8. Publication
 1. Topographic Maps
 2. Geologic Maps and Descriptive Text
 3. Description of the Mineral Resources of the United States
 4. Papers on Geological and Related Subjects
 5. Papers on Water Resources
 6. Miscellaneous
9. Operation of Engraving and Printing Plant

APPENDIX 3

PUBLICATIONS

Topographic Maps and Folios and Geologic Folios

The topographic maps and folios and the geologic folios issued by the United States Geological Survey may be obtained from the Director of the United States Geological Survey, Washington, D. C.

A large pamphlet, issued by the Survey, entitled "Topographic Maps and Folios and Geologic Folios" contains a list of all the topographic maps and folios and the geologic folios. A list of the geologic folios is also contained in a Survey publication entitled "Publications of the United States Geological Survey." The Survey publishes a set of "index circulars" which show the maps and folios completed for different regions of the country and the stages of the work in areas for which maps and folios are in preparation. In addition the Survey has prepared a circular which gives a list of the maps which illustrate various physiographic types and a general circular in regard to the geologic folios.

Topographic Maps and Folios

The topographic maps and folios published by the Survey fall into three classes:

1. Topographic Atlas Sheets
2. Topographic Folios
3. Special Topographic Maps

Topographic Atlas Sheets. Under this title are published by far the greatest number of topographic maps. The price of each standard atlas sheet is 10 cents.

Topographic Folios. Three topographic folios, consisting of separate topographic atlas sheets, assembled to illustrate types of topography, have been published. No others are projected. The price of two of these folios is 25 cents each. The price of the other folio is 50 cents.

Special Topographic Maps. These usually consist of several topographic atlas sheets or parts of sheets combined on a single sheet, sometimes on a larger or smaller scale than the regular sheets.

Geologic Folios

The geologic folios published by the Survey fall into three classes

1. Geologic Atlas Folios
2. Geologic Atlas Sheets
3. Special Geologic Maps

Geologic Atlas Folios. Under this title data regarding geologic conditions is presented. A folio contains both maps and descriptive matter. The price of folios ranges from 25 cents a copy to \$1.00 a copy, except that certain folios damaged by fire and water in 1913 are obtainable at 5 cents a copy.

Geologic Atlas Sheets. Separate sheets forming a part of the geologic folios are issued under this title in order to avoid the necessity for supplying an entire folio when one or two sheets will meet the requirements of persons desiring certain special data. The price of each sheet is 10 cents.

Special Geologic Maps. Only a few maps of this kind have been issued. They are prepared in order to present conditions at some particular place or in a way different from that employed in geologic folios. The prices of the several special maps are listed in the pamphlets and index circulars above mentioned.

Other Publications

The remaining publications of the Survey, with the exception of Monographs, may be obtained free from the Director of the United States Geological Survey as long as the Survey's supply lasts. It is possible then in some cases to purchase such publications from the Superintendent of Documents, Government Printing Office, Washington, D. C. All Monographs are obtainable only from the Superintendent of Public Documents and at prices stated.

These publications of the Survey are listed in a large pamphlet entitled, "The Publications of the U. S. Geological Survey," the latest volume of which was issued in December, 1916. This pamphlet is supplemented from time to time by the issue of circular lists of new publications. These publications are:

- Mineral Resources of the United States

- Technical treatises on geologic and related scientific subjects

 - Monographs

 - Professional Papers

 - Bulletins

- Water Supply Papers

- Annual Report of Director

- Miscellaneous

Mineral Resources of the United States. Each year the Survey issues one or two volumes entitled "Mineral Resources of the United States." These publications are, on request, distributed gratuitously as long as the Survey's stock lasts.

Technical Treatises on Geological and Related Scientific Subjects. These publications are classified as Bulletins, Professional Papers, and Monographs, the line of demarcation being based upon the extensiveness and exhaustiveness of the work. The Bulletins and Professional Papers are distributed gratuitously as long as the Survey's stock lasts. The Monographs are sold at prices ranging from eighty cents up.

Reference has been made in Chapter II to the tourist guide-books of the western United States issued for the first time in 1915 and listed under the title of Bulletins. Like other Bulletins these guide-books are distributed gratuitously as long as the Survey's supply lasts.

Water Supply Papers. A number of these papers are published each year. They may be obtained free until the Survey's stock is exhausted.

Annual Report of the Director. The annual report of the Director gives general information regarding the operations of the Survey during the year to which it relates. It differs in no essential respect from the annual reports of other administrative officers.

Miscellaneous (Special Publications). The miscellaneous or special publications of the Survey consist of pamphlets or books relating to office or field administration, a press bulletin announcing the publication of the Survey's reports, and other matter designed to advertise them or to inform the public of their nature.

APPENDIX 4

LAWS

(A) INDEX TO LAWS

Creation

Geological Survey established.....	20	Stat. L., 394
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Positions established

Director	20	Stat. L., 394
Acting Director	28	Stat. L., 197

Method of appointment of

Director	20	Stat. L., 394
Acting Director	28	Stat. L., 197
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Restrictions on

Director	20	Stat. L., 394
Members	20	Stat. L., 394

Duties of

Director	20	Stat. L., 394
Acting Director	28	Stat. L., 197

Salaries of

Director	40	Stat. L., 144
Certain scientific assistants.....	40	Stat. L., 144
Certain clerks, photographers, copyists, etc.....	40	Stat. L., 144

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General administration

Pay of field employees, assignments may be permitted	34	Stat. L., 727
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Facilities for research and illustration to be accessible to scientific investigators, etc.....	27	Stat. L., 395
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*Activities.—Cont.*General administration.—*Cont.*

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Base level to be determined and marked by posts or bench marks.....	29	Stat. L., 435
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Publications ¹		
In general		
Of what to consist.....	32	Stat. L., 741
Size of editions	32	Stat. L., 741
Transmission to Library of Congress of copies of	32	Stat. L., 741
Specific publications		
Specific estimates and appropriations required prior to publication		
Scientific reports known as monographs and bulletins	24	Stat. L., 255
Engravings for annual reports or for monographs or bulletins	24	Stat. L., 255
Engravings of illustrations, sections and maps	24	Stat. L., 255
Size of page (of annual report of Director, monographs, professional papers, bulletins, mineral resources, water supply and irrigation papers)	32	Stat. L., 741
Number of volumes: annual report of the Director	32	Stat. L., 741
Gratuitous distribution of		
To public libraries—		
Special memoirs and reports.....	24	Stat. L., 647
Monographs, bulletins and reports.....	29	Stat. L., 465
Sale publications	32	Stat. L., 741
To foreign governments, literary and scientific associations, etc.—		
Topographic and geologic maps and atlases	29	Stat. L., 701
Generally—bulletins and professional papers	32	Stat. L., 741

¹The provisions of the acts of Mar. 3, 1879, and March 2, 1895 (20 Stat. L., 394 and 28 Stat. L., 960) relative to publications are not here indexed. See note on p. 113.

*Items of appropriation*¹

Salaries

Office of Director

Director	40	Stat. L., 144
Chief Clerk	40	Stat. L., 144
Chief disbursing clerk.....	40	Stat. L., 144
Librarian	40	Stat. L., 144
Photographer	40	Stat. L., 144
Assistant photographers (2).....	40	Stat. L., 144
Clerks (5)	40	Stat. L., 144
Copyists (4)	40	Stat. L., 144
Watchmen (4)	40	Stat. L., 144
Janitor (1)	40	Stat. L., 144
Messenger boys (4)	40	Stat. L., 144

Scientific assistants

Geologists (2)	40	Stat. L., 144
Paleontologists (2)	40	Stat. L., 144
Chemist (1)	40	Stat. L., 144
Geographers (2)	40	Stat. L., 144
Topographers (2)	40	Stat. L., 144

Skilled laborers and various temporary employees

40 Stat. L., 144

Purchase of books, directories and scientific periodicals

40 Stat. L., 144

Specific activities

Topographic surveys

In various portions of the United States.....40 Stat. L., 144

Of public lands designated or to be designated
as national forests

40 Stat. L., 144

Geologic surveys in various portions of the
United States

40 Stat. L., 144

Chemical and physical researches relating to
geology

40 Stat. L., 144

Examination and classification of lands for de-
termination of suitability for enlarged home-
steads, etc.

40 Stat. L., 144

Preparation of report on mineral resources....40 Stat. L., 144

Investigation of mineral resources of Alaska....40 Stat. L., 144

Gauging streams and other water resources in-
vestigations, and preparation of reports....40 Stat. L., 144Discovering, developing, etc., springs, streams,
etc., on arid public lands, etc.....40 Stat. L., 144

Preparation of illustrations.....40 Stat. L., 144

Engraving of illustrations for annual report of
Director and other publications.....40 Stat. L., 174

Engraving and printing

Geologic maps

40 Stat. L., 174

Topographic data collected for War Depart-
ment

40 Stat. L., 174

Printing and binding of publications.....40 Stat. L., 174

¹ All the items under this head are found in the appropriation act for the fiscal year ending June 30, 1918, approved June 12, 1917.

(B) COMPILATION OF LAWS

1879—Act of March 3, 1879; 20 Stat. L., 394. (An act making appropriations for sundry civil expenses of the government for the fiscal year ending June thirtieth, eighteen hundred and eighty, and for other purposes.)

For the salary of the Director of the Geological Survey, which office is hereby established, under the Interior Department, who shall be appointed by the President by and with the advice and consent of the Senate, six thousand dollars: Provided, That this officer shall have the direction of the Geological Survey, and the classification of the public lands and examination of the geological structure, mineral resources and products of the national domain. And that the Director and members of the Geological Survey shall have no personal or private interests in the lands or mineral wealth of the region under survey, and shall execute no surveys or examinations for private parties or corporations; and the Geological and Geographical Survey of the Territories, and the Geographical and Geological Survey of the Rocky Mountain Region, under the Department of the Interior, and the Geographical Surveys West of the One-hundredth Meridian, under the War Department, are hereby discontinued, to take effect on the thirtieth day of June, eighteen hundred and seventy-nine. And all collections of rocks, minerals, soils, fossils, and objects of natural history, archæology, and ethnology, made by the Coast and Interior Survey, the Geological Survey, or by any other parties for the Government of the United States, when no longer needed for investigations in progress shall be deposited in the National Museum.¹

1880—Act of June 16, 1880; 21 Stat. L., 274. (An act making appropriations for the sundry civil expenses of the government for the fiscal year ending June thirtieth, eighteen hundred and eighty-one, and for other purposes.)

And the Secretary of War is hereby authorized to detail not exceeding two officers of the Ordnance Corps to serve with the Geological Survey: Provided, That in his judgment it can be done without injury to the Service.

¹ Provision was further made in this act for the publication of an annual report of operations to "accompany the annual report of the Secretary of the Interior" and for the publication of special memoirs and reports to "be issued in uniform quarto series if deemed necessary by the Director, but otherwise in ordinary octavos." While not specifically repealed these provisions are doubtless to be regarded as superseded by the Joint Resolution of May 16, 1902 (32 Stat. L., 741).

1884—Act of July 5, 1884; 23 Stat. L., 111. (An act making appropriations for the support of the army for the fiscal year ending June thirtieth, eighteen hundred and eighty-five, and for other purposes.)

Provided also, That hereafter the Quartermaster-General and his officers, under his instructions, wherever stationed, shall receive, transport, and be responsible for all property turned over to them, or any one of them, by the officers or agents of any Government survey, for the National Museum, or for the civil or naval departments of the Government, in Washington or elsewhere, under the regulations governing the transportation of Army supplies, the amount paid for such transportation to be refunded or paid by the Bureau to which such property or stores pertain.

1884—Act of July 7, 1884; 23 Stat. L., 194. (An act making appropriations for sundry civil expenses of the government for the fiscal year ending June thirtieth, eighteen hundred and eighty-five, and for other purposes.)

And the scientific employees of the Geological Survey shall be selected by the Director, subject to the approval of the Secretary of the Interior, exclusively for their qualifications as professional experts.

1886—Act of August 4, 1886; 24 Stat. L., 255. (An act making appropriations for sundry civil expenses of the government for the fiscal year ending June thirtieth, eighteen hundred and eighty-seven, and for other purposes.)

And hereafter the scientific reports known as the monographs and bulletins of the Geological Survey shall not be published until specific and detailed estimates are made therefor, and specific appropriations made in pursuance of such estimates; and no engraving for the annual reports or for such monographs and bulletins, or of illustrations, sections, and maps, shall be done until specific estimates are submitted therefor and specific appropriations made based on such estimates: Provided further, That all printing and engraving for the Geological Survey, and Coast and Geodetic Survey, the Hydrographic office of the Navy Department, and the Signal Service shall hereafter be estimated for separately and in detail, and appropriated for separately for each of said Bureaus.¹

¹ The provisions of the above act from the words "the scientific reports known, etc.," to the words "based on such estimates" were reenacted in the act of January 12, 1895; 28 Stat. L., 621.

1887—Act of March 3, 1887; 24 Stat. L., 509. (An act making appropriations for sundry civil expenses of the government for the fiscal year ending June thirtieth, eighteen hundred and eighty-eight, and for other purposes.)

Hereafter the estimates for the Geological Survey shall be itemized.

1887—Act of March 3, 1887; 24 Stat. L., 647. (Joint resolution to distribute copies of special memoirs and reports of the United States Geological Survey.)

Resolved, etc., That there shall be distributed from the number of special memoirs and reports of the United States Geological Survey now authorized by law one copy of every such publication to every public library which shall be designated to the Secretary of the Interior as follows:

Two public libraries to be designated by each of the Senators from the States, respectively, two public libraries by the Representative in Congress from every Congressional district and two public libraries by the Delegate from every Territory; such public libraries to be additional to those to which the said publications are distributed under existing law.

1892—Act of April 12, 1892; 27 Stat. L., 395. (Joint resolution to encourage the establishment and endowment of institutions of learning at the national capital by defining the policy of the government with reference to the use of its literary and scientific collections by students.)

Resolved, by the Senate and House of Representative of the United States of America, in Congress assembled, That the facilities for research and illustration in the following and any other governmental collections now existing or hereafter to be established in the city of Washington for the promotion of knowledge shall be accessible, under such rules and restrictions as the officers in charge of each collection may prescribe, subject to such authority as is now or may hereafter be permitted by law, to the scientific investigators and to students of any institution of higher education now incorporated or hereafter to be incorporated under the laws of Congress or of the District of Columbia, to wit:

* * *

Of the Geological Survey.

1894—Act of July 31, 1894; 28 Stat. L., 197. (Legislative, Executive and Judicial Appropriation Act.)

The Secretary of the Interior may hereafter authorize one of the geologists to act as Director of the Geological Survey in the absence of that officer.

1896—Act of June 11, 1896¹; 29 Stat. L., 435. (An act making appropriations for sundry civil expenses of the government for the fiscal year ending June thirtieth, eighteen hundred and ninety-seven, and for other purposes.)

United States Geological Survey. * * * For topographic surveys in various portions of the United States * * * Provided, That hereafter in such surveys west of the ninety-fifth meridian elevations above a base level located in each area under survey shall be determined and marked on the ground by iron or stone posts or permanent bench marks, at least two such posts or bench marks to be established in each township or equivalent area except in the forest-clad and mountain areas, where at least one shall be established, and these shall be placed, whenever practicable, near the township corners of the public land surveys; and in the areas east of the ninety-fifth meridian at least one such post or bench mark shall be similarly established in each area equivalent to the area of a township of the public land surveys. * * *

1896—Act of February 26, 1896; 29 Stat. L., 465. (Joint resolution extending the provisions of section seventy-nine of "An Act providing for the public printing and binding and the distribution of public docu-

¹The Act of March 2, 1895, provided for the incorporation into the report of the Director of the report of the mineral resources of the United States, and made the further provision "and that the separate chapters on any given mineral product, such as iron, coal, building stone, and so forth, shall be printed as rapidly as transmitted for publication; that a pamphlet edition of any chapter shall be printed for distribution on the request of the Director of the Geological Survey, approved by the Secretary of the Interior, the size of the edition to be controlled by the importance of the mineral treated; that hereafter papers for the Director's annual report that are of a strictly economic character shall be issued in pamphlet form, in the same manner as prescribed above for the report on the mineral resources; that the entire cost of paper, printing, and binding of all of the above provided for pamphlets shall not exceed two thousand dollars." While not specifically repealed, these provisions are doubtless to be regarded as superseded by the Joint Resolution of May 16, 1902 (32 Stat. L., 741).

ments," approved January twelfth, eighteen hundred and ninety-five, so as to include monographs, bulletins, and reports of the Geological Survey published in eighteen hundred and ninety-four and succeeding years.)

Resolved, by the Senate and House of Representatives of the United States of America in Congress assembled, That the provisions of section seventy-nine of "An Act providing for the public printing and binding and the distribution of public documents," approved January twelfth, eighteen hundred and ninety-five, which section reads as follows: "There shall be distributed of monographs, bulletins, and reports of the United States Geological Survey, now in possession of said Survey, being publications prior to the year eighteen hundred and ninety-four, one copy of every such publication to every public library which shall be designated to the superintendent of documents, as follows: Two public libraries to be designated by each of the Senators from the States, respectively, two public libraries by the Representatives in Congress, from each Congressional district, and two public libraries by the delegate from each Territory; such public libraries to be additional to those to which said publications are distributed under existing law," shall be extended to the monographs, bulletins and reports of the Geological Survey which were published during the year eighteen hundred and ninety-four, and to those which have been published since that year, and to those which may be published in the future: Provided, That nothing herein contained shall be construed to interfere with the distribution of memoirs and reports, so far as the same is provided for by the joint resolution "To distribute copies of special memoirs and reports of the United States Geological Survey," approved March third, eighteen hundred and eighty-seven.

1897—Act of February 18, 1897; 29 Stat. L., 701. (Joint resolution providing for the distribution of the maps and atlases of the United States Geological Survey.)

Resolved, etc., That the Director of the Geological Survey be, and is hereby authorized and directed, on the approval of the Secretary of the Interior, to dispose of the topographic and geologic maps and atlases of the United States Geological Survey, * * * at such prices and under such regulations as may from time to time be fixed by him and approved by the Secretary of the Interior;

And that a number of copies of each map or atlas, not exceeding five hundred, shall be distributed gratuitously among foreign governments and departments of our own government, to literary and scientific associations, and to such educational institutions or libraries as may be designated by the Director of the Survey and approved by the Secretary of the Interior. * * *

1899—Act of March 3, 1899; 30 Stat. L., 1074. (An act making appropriations for sundry civil expenses of the government for the fiscal year ending June thirtieth, nineteen hundred, and for other purposes.)

That hereafter all standard, meander, township, and section lines of the public land surveys shall, as heretofore, be established under the direction and supervision of the Commissioner of the General Land Office, whether the lands to be surveyed are within or without reservations, except that where the exterior boundaries of public forest reservations are required to be coincident with standard, township or section lines such boundaries may, if not previously established in the ordinary course of the public land surveys, be established and marked under the supervision of the Director of the United States Geological Survey whenever necessary to complete the survey of such exterior boundaries. * * *

1902—Act of June 28, 1902; 32 Stat. L., 455. (An act making appropriations for sundry civil expenses of the government for the fiscal year ending June thirtieth, nineteen hundred and three, and for other purposes.)

Hereafter, in lieu of the specific estimates for personal services now required by law, there shall be submitted in the Annual Book of Estimates under each item of appropriation under "General Expenses of the Geological Survey," notes showing the number of persons employed and the rate of compensation paid to each from each of said appropriations during the fiscal year next preceding the fiscal year for which estimates are submitted.

Provided, That the purchase of professional and scientific books and periodicals needed for statistical purposes hereafter by the scientific divisions of the United States Geological Survey is hereby authorized to be made and paid for out of appropriations made for the said Survey.

1902—Act of May 16, 1902; 32 Stat. L., 741. (Joint resolution relating to publications of the Geological Survey.)

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That hereafter the publications of the Geological Survey shall consist of the annual report of the Director, which shall be confined to one volume of royal octavo size; monographs, of quarto size; professional papers, of quarto size; bulletins, of ordinary octavo size; mineral resources, of

ordinary octavo size; water-supply and irrigation papers, of ordinary octavo size; and such maps, folios, and atlases as may be required by existing law:

That hereafter the reports of the Geological Survey, except the annual report of the Director, shall be published in editions as recommended in each case by the Director and approved by the Secretary of the Interior, but not to exceed ten thousand copies.

That whenever the edition of any of the reports of the Survey shall have become exhausted, and the demand for it continues, there shall be published, on the requisition of the Secretary of the Interior, as many additional copies of the report as the Director of the Survey shall state will, in his judgment, be necessary to meet the demand.

That the bulletins and professional papers shall be distributed gratuitously, and not sold; and that of the number published one thousand copies shall be delivered to the Senate and two thousand copies shall be delivered to the House of Representatives for distribution.

That the Director of the Survey shall transmit to the Library of Congress two copies of every report of the Bureau as soon as the first delivery to the Survey is made, such copies to be additional to those received by the Library of Congress under existing law.

1903—Act of March 3, 1903; 32 Stat. L., 1146. (An Act making appropriations for sundry civil expenses of the government for the fiscal year ending June thirtieth, nineteen hundred and four, and for other purposes.)

And the Director of the Geological Survey shall hereafter distribute to public libraries that have not already received them such copies of sale publications as may remain on hand at the expiration of five years after date of delivery to the Survey document room, excepting a reserve number not to exceed two hundred copies.

1906—Act of June 30, 1906; 34 Stat. L., 727, 728. (An Act making appropriations for sundry civil expenses of the government for the fiscal year ending June thirtieth, nineteen hundred and seven, and for other purposes.)

The Secretary of the Interior is hereby authorized to permit scientific and other employees of the United States Geological Survey, employed in the field, to make assignments of their pay, under such regulations as he may prescribe, during such time as they may be in the employ of the United States Geological Survey. And the Secretary of the Interior is further authorized, in his discretion, under

such regulations as he may prescribe, to reimburse the scientific and other employees for expenses incurred by them in the discharge of their duties in the field and paid from their personal funds.

The Director of the Geological Survey shall, if the regular map work of the Survey is in no wise interfered with thereby, hereafter furnish to any person, concern, institution, State or foreign government, that shall pay in advance the whole cost thereof with ten per centum added, transfers or copies of any cartographic or other engraved or lithographic data in the division of engraving and printing of the Survey, and the moneys received by the Director for such transfers or copies shall be deposited in the Treasury.

1909—Act of March 4, 1909; 35 Stat. L., 989. (An act making appropriations for sundry civil expenses of the government for the fiscal year ending June thirtieth, nineteen hundred and ten, and for other purposes.)

The Director of the Geological Survey shall hereafter furnish to any person, concern, or institution, in the interest of education and the dissemination of knowledge, that shall pay in advance the whole cost of material and services thereof, copies of any photographs or lantern slides in the possession of the United States Geological Survey; and the moneys received by the Director for the same shall be deposited in the United States Treasury.

1911—Act of March 1, 1911; 36 Stat. L., 961. (An Act to enable any state to coöperate with any other state or states, or with the United States, for the protection of the watersheds of navigable streams, and to appoint a commission for the acquisition of lands for the purpose of conserving the navigability of navigable rivers.)

Provided that before any lands are purchased by the National Forest Reservation Commission said lands shall be examined by the Geological Survey and a report made to the Secretary of Agriculture, showing that the control of such lands will promote or protect the navigation of streams on whose watersheds they lie.

1917—Act of June 12, 1917; 40 Stat. L., 144, 174. (An act making appropriations for sundry civil expenses of the government for the fiscal year ending June thirtieth, nineteen hundred and eighteen, and for other purposes.)

UNITED STATES GEOLOGICAL SURVEY

Office of Director: Director, \$6,000; chief clerk, \$2,500; chief disbursing clerk, \$2,500; librarian, \$2,000; photographer, \$2,000; assistant photographers—one \$900, one \$720; clerk—one of class two, three of class one, one \$1,000, four at \$900 each; four copyists, at \$720 each; watchmen—one \$840, four at \$720 each; janitor, \$600; four messenger boys, at \$480 each; in all, \$35,340;

Scientific assistants: Geologists—two at \$4,000 each, one \$3,000, one \$2,700; two paleontologists, at \$2,000 each; chemist, \$3,000; geographers—one \$2,700, one \$2,500; two topographers, at \$2,000 each; in all, \$29,900;

General expenses: For every expenditure requisite for and incident to the authorized work of the Geological Survey, including personal services in the District of Columbia and in the field, including the purchase, hire, maintenance, repair, and operation of motor-propelled and horse-drawn passenger-carrying vehicles for field use only by geologists, topographers, and engineers, to be expended under the regulations from time to time prescribed by the Secretary of the Interior, and under the following heads: *Provided*, That hereafter the purchase of supplies or the procurement of services outside the District of Columbia may be made in open market in the manner common among business men when the aggregate amount of the purchase does not exceed \$50;

For pay of skilled laborers and various temporary employees, \$20,000;

For topographic surveys in various portions of the United States, \$350,000: *Provided*, That in expending this sum preference shall be given special topographic surveys of areas selected by the War Department and in securing such extra topographic data as are requested by the War Department in these or other areas;

For geologic surveys in the various portions of the United States, \$350,000;

For continuation of the investigation of the mineral resources of Alaska, \$100,000, to be immediately available;

For chemical and physical researches relating to the geology of the United States, including researches with a view of determining geological conditions favorable to the presence of deposits of potash salts, \$40,000;

For preparation of the illustrations of the Geological Survey, \$18,280;

For preparation of the report of the mineral resources of the United States, \$75,000;

For gauging streams and determining the water supply of the United States, the investigation of underground currents and artesian wells, and the preparation of reports upon the best methods of utilizing the water resources, \$175,000, of which \$25,000 may be used to test the existence of artesian and other underground water supplies suitable for irrigation in the arid and semiarid regions by boring wells;

For purchase of necessary books for the library, including directories and professional and scientific periodicals needed for statistical purposes, \$2,000;

For discovering, developing, protecting, and rendering more accessible, springs, streams, and water holes on arid public lands of the United States; for erecting and maintaining suitable and durable monuments and signboards; and for providing convenient and ready means, apparatus, and appliances by which water may be brought to the earth's surface, \$10,000;

For engraving and printing geologic maps, \$120,000;

For continuation of topographic surveys of the public lands that have been or may hereafter be designated as national forests, \$75,000;

For the examination and classification of lands requisite to the determination of their suitability for enlarged homesteads, stock-raising homesteads, public watering places, and stock driveways, as required by the public land laws, to be immediately available, \$150,000;

In all, United States Geological Survey, \$1,550,520.

GOVERNMENT PRINTING OFFICE

For the United States Geological Survey: For engraving the illustrations necessary for the annual report of the director, and for the monographs, professional papers, bulletins, water-supply papers, and the report on mineral resources, and for printing and binding the same publications, of which sum not more than \$45,000 may be used for engraving, \$175,000.

APPENDIX 5

FINANCIAL STATEMENTS

EXPLANATORY NOTE

Statements showing appropriations, receipts, expenditures and other financial data for a series of years constitute the most effective single means of exhibiting the growth and development of a service. Due to the fact that Congress has adopted no uniform plan of appropriations for the several services and that the latter employ no uniform plan in respect to the recording and reporting of their receipts and expenditures, it is impossible to present data of this character according to any standard scheme of presentation. In the case of some services the administrative reports contain tables showing financial conditions and operations of the service in considerable detail; in others financial data are almost wholly lacking. Careful study has in all cases been made of such data as are available, and the effort has been made to present the results in such a form as will exhibit the financial operations of the service in the most effective way that circumstances permit.

THE U. S. GEOLOGICAL SURVEY

UNITED STATES GEOLOGICAL SURVEY.

APPROPRIATIONS: 1880 TO 1918, INCLUSIVE.

Appropriation	1880	1881	1882	1883	1884	1885	1886	1887
Expenses of the Geological Survey and the classification of public lands and the examination of the geologic structures, mineral resources, and products of the national domain...	\$100,000.00	\$148,500.00	\$148,500.00	\$222,000.00	\$240,000.00	\$386,000.00	\$400,000.00	\$400,000.00
Salaries, Office of Geological Survey...	6,000.00	6,000.00	6,000.00	34,940.00	34,940.00	35,340.00	35,540.00	35,540.00
Salaries, Scientific Assistants...					64,700.00	67,700.00	67,700.00	67,700.00
Skilled Laborers and various Temporary Employees...								
Topographic Surveys...								
Geologic Surveys...								
Paleontologic Researches...								
Gaging Streams, Etc.								
Chemical and Physical Researches...								
Mineral Resources of the United States...								
Mineral Resources of Alaska...								
Surveying National Forests...								
Testing Fuel...								
Testing Structural Materials of U.S. Inspecting Mine Accidents...								
Inspecting Mines in Territories...								
Geologic Maps of the United States...								
Preparation of Illustrations...								
Special Surveys and Miscellaneous Activities...								
Books for the Library...								
Printing and Binding...								
Rent...		1,500.00	1,500.00	1,500.00	1,500.00			10,000.00
Total...	\$106,000.00	\$156,000.00	\$156,000.00	\$258,440.00	\$341,140.00	\$489,040.00	\$503,240.00	\$513,240.00

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APPROPRIATIONS: 1880 TO 1918, INCLUSIVE—Continued.

Appropriation	1888	1889	1890	1891	1892	1893	1894	1895
Expenses of the Geological Survey and the classification of public lands and the examination of the geologic structures, mineral resources, and products of the national domain...	\$400,000.00							
Salaries, Office of Geological Survey...	35,540.00	\$35,540.00	\$35,540.00	\$35,540.00	\$35,540.00	\$35,540.00	\$35,540.00	\$31,634.57
Salaries, Scientific Assistants...	67,700.00	67,700.00	67,700.00	67,700.00	67,700.00	33,332.88	29,900.00	29,900.00
Skilled Laborers and various Temporary Employees...		15,000.00	15,000.00	15,000.00	15,000.00	10,000.00	13,000.00	13,000.00
Topographic Surveys...		199,000.00	200,000.00	329,573.38	250,000.00	240,000.00	200,000.00	150,000.00
Geologic Surveys...		100,000.00	100,000.00	115,000.00	115,000.00	50,000.00	70,000.00	100,000.00
Paleontologic Researches...		40,000.00	40,000.00	40,000.00	40,000.00	10,000.00	10,000.00	10,000.00
Gaging Streams, Etc.								12,500.00
Chemical and Physical Researches		17,000.00	17,000.00	17,000.00	17,000.00	5,000.00	5,000.00	7,000.00
Mineral Resources of the United States		10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	12,000.00	17,000.00
Mineral Resources of Alaska								
Surveying National Forests								
Testing Fuel								
Testing Structural Materials of U.S.								
Investigating Mine Accidents								
Geologic Maps of the United States			45,000.00	70,000.00	60,000.00	20,000.00	55,000.00	65,000.00
Preparation of Illustrations		16,000.00	16,000.00	16,000.00	16,000.00	10,000.00	13,000.00	13,000.00
Special Surveys and Miscellaneous Activities		100,000.00	250,000.00	41,095.89				
Books for the Library (1)		5,000.00	5,000.00	5,000.00	2,500.00	2,000.00	2,000.00	3,000.00
Printing and Binding	122,000.00	122,000.00	68,000.00	68,000.00	63,000.00	48,000.00	35,000.00	35,000.00
Rent	10,000.00	10,000.00	10,000.00	13,200.00	13,200.00	14,200.00	14,200.00	14,200.00
Total	\$635,240.00	\$737,240.00	\$879,240.00	\$843,109.27	\$704,940.00	\$488,072.88	\$494,640.00	\$501,234.57

(1) From 1889 to 1904, inclusive, the amounts of appropriations appearing in this column include payments for transmission of public documents through the Smithsonian Exchange.

APPROPRIATIONS: 1880 TO 1918, INCLUSIVE—Continued.

Appropriation	1896	1897	1898	1899	1900	1901	1902	1903
Expenses of the Geological Survey and the classification of public lands and the examination of the geologic structures, mineral resources, and products of the national domain.	\$31,300.00	\$31,300.00	\$31,300.00	\$31,300.00	\$31,300.00	\$31,300.00	\$32,300.00	\$32,300.00
Salaries, Office of Geological Survey.	29,900.00	29,900.00	29,900.00	29,900.00	29,900.00	29,900.00	29,900.00	29,900.00
Salaries, Scientific Assistants.								
Skilled Laborers and various Temporary Employees.	13,000.00	13,000.00	13,000.00	13,000.00	13,000.00	13,000.00	16,000.00	20,000.00
Topographic Surveys.	150,000.00	175,000.00	175,000.00	180,000.00	240,000.00	240,000.00	250,000.00	300,000.00
Geologic Surveys.	100,000.00	100,000.00	100,000.00	110,000.00	110,000.00	150,000.00	150,000.00	150,000.00
Paleontologic Researches.	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00
Gaging Streams, Etc.	24,500.00	50,000.00	50,000.00	50,000.00	70,000.00	100,000.00	100,000.00	200,000.00
Chemical and Physical Researches.	8,500.00	7,000.00	7,000.00	7,000.00	7,000.00	10,000.00	20,000.00	20,000.00
Mineral Resources of the United States.	18,000.00	20,000.00	20,000.00	20,000.00	30,000.00	50,000.00	50,000.00	50,000.00
Mineral Resources of Alaska (1).	5,000.00	5,000.00	5,000.00	5,000.00	25,000.00	60,000.00	60,000.00	60,000.00
Surveying National Forests (2).			150,000.00	150,000.00	130,000.00	130,000.00	130,000.00	13,000.00
Testing Fuel.								
Investigating Mine Accidents.								
Geologic Maps of the United States.	65,000.00	60,000.00	60,000.00	60,000.00	62,500.00	80,000.00	75,000.00	100,000.00
Preparation of Illustrations.	13,000.00	13,000.00	13,000.00	14,000.00	14,000.00	14,000.00	16,280.00	18,280.00
Special Surveys and Miscellaneous Activities.	200,000.00	208,000.00	279,150.00	55,889.60	4,338.45	12,000.00	7,830.00	7,200.00
Books for the Library (3).	4,230.60	2,000.00	4,319.25	4,997.75	6,912.44	7,620.00	5,000.00	6,000.00
Printing and Binding.	41,000.00	37,000.00	37,000.00	77,000.00	37,000.00	37,000.00	45,000.00	215,000.00
Rent.	14,600.00	15,400.00	15,400.00	17,400.00	17,400.00	22,400.00	25,400.00	28,400.00
Total.	\$728,120.60	\$776,690.00	\$1,000,159.25	\$835,577.35	\$838,440.89	\$997,310.00	\$1,022,800.00	\$1,377,179.00

(1) Appropriations for the years 1896 to 1901, inclusive, were for "Coal and gold resources of Alaska."

(2) Appropriations for the years 1898 to 1910, inclusive, were for "Surveying Forest Reserves."

(3) From 1880 to 1904, inclusive, the amounts of appropriations appearing in this column include payments for transmission of public documents through the Smithsonian Exchange.

APPROPRIATIONS: 1880 TO 1918, INCLUSIVE—Continued.

Appropriation	1904	1905	1906	1907	1908	1909	1910	1911
Expenses of the Geological Survey and the classification of public lands and the examination of the geologic structures, mineral resources, and products of the national domain...								
Salaries, Office of Geological Survey...	\$32,740.00	\$32,740.00	\$32,740.00	\$35,340.00	\$35,340.00	\$35,340.00	\$34,860.00	\$34,860.00
Salaries, Scientific Assistants...	29,900.00	29,900.00	29,900.00	29,900.00	29,900.00	29,900.00	29,900.00	29,900.00
Skilled Laborers and various Temporary Employees...	20,000.00	20,000.00	20,000.00	20,000.00	20,000.00	20,000.00	20,000.00	20,000.00
Topographic Surveys...	300,000.00	300,000.00	350,000.00	350,000.00	300,000.00	300,000.00	350,000.00	350,000.00
Geologic Surveys...	150,000.00	175,000.00	200,000.00	200,000.00	200,000.00	200,000.00	225,000.00	300,000.00
Paleontologic Researches (1)...	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00
Gaging Streams, Etc...	200,000.00	200,000.00	200,000.00	150,000.00	100,000.00	100,000.00	100,000.00	150,000.00
Chemical and Physical Researches (2)...	20,000.00	20,000.00	20,000.00	20,000.00	20,000.00	20,000.00	20,000.00	20,000.00
Mineral Resources of the United States...	60,000.00	50,000.00	100,000.00	75,000.00	75,000.00	75,000.00	75,000.00	75,000.00
Mineral Resources of Alaska...	60,000.00	80,000.00	80,000.00	80,000.00	80,000.00	80,000.00	90,000.00	90,000.00
Surveying National Forests (3)...	130,000.00	130,000.00	130,000.00	100,000.00	100,000.00	100,000.00	75,000.00	75,000.00
Testing Fuel...		60,000.00	227,000.00	250,000.00	250,000.00	250,000.00	100,000.00	100,000.00
Testing Structural Materials of U.S. (4)			12,500.00	100,000.00	100,000.00	100,000.00	100,000.00	100,000.00
Investigating Mine Accidents...						150,000.00	150,000.00	150,000.00
Inspecting Mines in Territories...						7,350.00	7,350.00	7,350.00
Geologic Maps of the United States...	100,000.00	100,000.00	100,000.00	100,000.00	100,000.00	100,000.00	100,000.00	100,000.00
Preparation of Illustrations...	18,280.00	18,280.00	18,280.00	18,280.00	18,280.00	18,280.00	18,280.00	18,280.00
Special Surveys and Miscellaneous Activities...			7,062.30			17,810.00	425.00	
Books for the Library...	10,857.77	10,500.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00
Printing and Binding...	6,000.00	2,000.00	215,000.00	185,000.00	185,000.00	175,000.00	175,000.00	175,000.00
Rent...	215,000.00	215,000.00	30,400.00	31,900.00	34,900.00	34,900.00	37,400.00	37,400.00
	28,400.00	30,400.00						
Total.....	\$1,391,177.77	\$1,483,820.00	\$1,784,882.30	\$1,757,420.00	\$1,660,420.00	\$1,800,580.00	\$1,710,215.00	\$1,477,440.00

(1) Combined with the appropriations for the geological survey beginning with the year 1910.

(2) Includes researches relating to deposits of potash salts during the last seven years.

(3) Appropriations for the years 1898 to 1910, inclusive, were for "Surveying Forest Reserves."

(4) Bureau of Mines was created in 1910, and thereafter appropriations for these activities were made under that unit.

APPROPRIATIONS: 1880 TO 1918, INCLUSIVE—Continued.

Appropriation	1912	1913	1914	1915	1916	1917	1918	Total
Expenses of the Geological Survey and the classification of public lands and the examination of the geologic structures, mineral resources, and products of the national domain.								
Salaries, Office of Geological Survey.	\$35,340.00	\$35,340.00	\$35,340.00	\$35,340.00	\$35,340.00	\$35,340.00	\$35,340.00	\$2,445,000.00
Salaries, Scientific Assistants.	29,900.00	29,900.00	29,900.00	29,900.00	29,900.00	29,900.00	29,900.00	1,249,174.57
Skilled Laborers and various Temporary Employees.	20,000.00	20,000.00	20,000.00	20,000.00	20,000.00	20,000.00	20,000.00	1,387,132.88
Topographic Surveys.	350,000.00	350,000.00	350,000.00	350,000.00	350,000.00	350,000.00	350,000.00	510,000.00
Geologic Surveys.	300,000.00	300,000.00	300,000.00	400,000.00	350,000.00	350,000.00	350,000.00	8,328,573.38
Paleontologic Researches.								5,020,000.00
Coring Streams, Etc.	150,000.00	150,000.00	150,000.00	150,000.00	150,000.00	150,000.00	175,000.00	330,000.00
Chemical and Physical Researches (1).	40,000.00	40,000.00	40,000.00	40,000.00	40,000.00	40,000.00	40,000.00	2,932,000.00
Mineral Resources of the United States.	75,000.00	75,000.00	75,000.00	75,000.00	75,000.00	75,000.00	75,000.00	611,500.00
Mineral Resources of Alaska.	100,000.00	90,000.00	100,000.00	100,000.00	100,000.00	100,000.00	100,000.00	1,447,000.00
Surveying National Forests.	75,000.00	75,000.00	75,000.00	75,000.00	75,000.00	75,000.00	75,000.00	1,555,000.00
Testing Fuel.								2,100,000.00
Testing Structural Materials of U.S. (2)								1,137,000.00
Investigating Mine Accidents.								412,500.00
Inspecting Mines in Territories.								300,000.00
Geologic Maps of the United States.	110,000.00	110,000.00	110,000.00	110,000.00	110,000.00	110,000.00	120,000.00	14,700.00
Preparation of Illustrations.	18,280.00	18,280.00	18,280.00	18,280.00	18,280.00	18,280.00	18,280.00	2,437,500.00
Special Surveys and Miscellaneous Activities.								489,760.00
Books for the Library.	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	1,372,159.01
Printing and Binding.	145,000.00	165,000.00	175,000.00	175,000.00	175,000.00	175,000.00	2,000.00	99,580.04
Rent.	37,400.00	37,400.00	37,400.00	40,000.00	40,000.00	40,000.00	175,000.00	3,812,500.00
Total.	\$1,487,920.00	\$1,497,920.00	\$1,517,920.00	\$1,620,520.00	\$1,570,520.00	\$1,570,520.00	\$1,725,520.00	\$39,439,879.88

(1) Includes researches relating to deposits of potash salts during the last seven years.

(2) Bureau of Mines was created in 1910, and thereafter appropriations for these activities were made under that unit.

FINANCIAL STATEMENTS

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STATE CONTRIBUTIONS: COÖPERATIVE TOPOGRAPHIC AND HYDROGRAPHIC WORK.¹

States	Prior to June 30, 1909 ²	1909-10	1910-11	1911-12	1912-13	1913-14	1914-15	1915-16	Total
Alabama: Topographic Work.....	\$6,000.00		\$800.00				\$3,032.78		\$9,832.78
Arizona: Hydrographic Work.....	994.00						170.00	\$200.00	1,364.00
California: Hydrographic Work.....					\$3,000.00	\$3,000.00	3,900.00	3,900.00	13,860.00
Topographic Work.....	80,000.00	\$14,000.00	14,000.00	\$21,000.00	17,600.00	16,500.00	14,000.00	14,000.00	191,100.00
Hydrographic Work.....	79,486.73	9,000.00	9,000.00	25,000.00	28,586.00	16,500.00	13,200.00	16,500.00	197,332.73
Colorado: Hydrographic Work.....	1,487.97		545.00	107.10			480.00	485.00	3,105.07
Connecticut: Topographic Work.....									
Hydrographic Work.....	24,599.00				1,000.00	1,000.00	1,000.00	1,555.00	24,599.00
Idaho: Topographic Work.....									
Hydrographic Work.....	2,000.00	2,000.00	5,000.00	12,000.00	700.00	9,000.00	1,900.00		700.00
Illinois: Topographic Work.....	36,000.00	17,500.00	13,750.00	13,750.00	8,000.00	11,500.00	9,000.00	12,000.00	121,500.00
Hydrographic Work.....	8,675.94	2,000.00	3,000.00	2,191.37			3,400.00	2,355.00	21,622.31
Iowa: Topographic Work.....	3,500.00	1,750.00	1,750.00	2,350.00	2,650.00	1,750.00	1,950.00	1,750.00	17,450.00
Hydrographic Work.....						500.00	450.00	500.00	1,450.00
Kansas: Hydrographic Work.....	413.03								413.03
Kentucky: Topographic Work.....	37,500.00	5,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	102,500.00
Hydrographic Work.....							670.00	315.00	985.00
Louisiana: Topographic Work.....	4,000.00	20,000.00							24,000.00
Maine: Topographic Work.....	26,700.00	3,500.00	4,500.00	4,700.00	3,726.42	4,900.00	4,000.00	5,000.00	57,026.42
Hydrographic Work.....	37,505.07	3,300.00	1,000.00	1,350.00			75.00	4,515.00	47,745.07
Maryland: Topographic Work.....	46,550.00	3,000.00	2,000.00	1,825.00					53,375.00
Hydrographic Work.....	3,400.00								3,400.00
Massachusetts: Topographic Work.....	40,000.00								40,000.00
Hydrographic Work.....	1,950.00	1,950.00	825.00	1,000.00	3,000.00	3,000.00	3,350.00	2,520.00	15,795.00
Michigan: Topographic Work.....	13,700.00	2,000.00	2,000.00	2,000.00	2,000.00	2,500.00	2,500.00	15,000.00	41,700.00

¹ In addition to the amounts appearing in this statement, funds have been appropriated by states for coöperative geologic surveys, complete records of which are not available.

² Amounts in this column are taken from pamphlet entitled "Coöperation between the United States and Various States in Topographic, Hydrographic and Geologic Work," published by the Survey in 1910.

STATE CONTRIBUTIONS: COOPERATIVE TOPOGRAPHIC AND HYDROGRAPHIC WORK¹—Continued.

States	Prior to June 30, 1909 ²	1909-10	1910-11	1911-12	1912-13	1913-14	1914-15	1915-16	Total
Minnesota:									
Topographic Work.....		\$10,000.00	\$8,000.00	\$10,000.00	\$10,362.48	\$10,000.00	\$4,500.00	\$4,250.00	\$57,112.48
Hydrographic Work.....	\$18,400.00	17,500.00	.....	16,000.00	3,650.00	3,500.00	2,100.00	2,400.00	63,550.00
Mississippi:									
Topographic Work.....	31,400.00	.....	.....	.....	.....	.....	.....	.....	31,400.00
Missouri:									
Topographic Work.....	6,000.00	4,500.00	4,000.00	6,000.00	2,500.00	10,000.00	5,221.74	4,000.00	42,221.74
Montana:									
Hydrographic Work.....	1,405.00	.....	.....	3,000.00	2,500.00	.....	2,500.00	2,875.00	12,280.00
Nebraska:									
Topographic Work.....	1,700.00	.....	.....	1,500.00	2,000.00	2,000.00	.....	1,750.00	7,250.00
Hydrographic Work.....	.....	.....	.....	.....	.....	.....	.....	.....	1,700.00
Nevada:									
Topographic Work.....	1,250.00	.....	.....	.....	385.00	2,500.00	1,800.00	3,140.00	9,075.00
New Hampshire:									
Hydrographic Work.....	1,300.00	.....	.....	.....	.....	.....	.....	.....	1,300.00
New Jersey:									
Topographic Work.....	19,670.00	.....	.....	.....	.....	.....	.....	.....	19,670.00
New Mexico:									
Hydrographic Work.....	2,500.00	2,500.00	3,170.93	4,258.15	14,174.00	12,000.00	7,200.00	.....	45,803.08
New York:									
Topographic Work.....	233,600.00	7,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	300,600.00
Hydrographic Work.....	21,373.91	5,000.00	11,089.69	13,476.30	11,500.00	11,500.00	11,900.00	13,800.00	99,639.90
North Carolina:									
Topographic Work.....	29,200.00	2,500.00	.....	.....	.....	.....	.....	.....	31,700.00
Hydrographic Work.....	576.25	.....	.....	.....	.....	.....	.....	.....	576.25
North Dakota:									
Hydrographic Work.....	.....	.....	.....	.....	.....	.....	.....	.....	850.00
Ohio:									
Topographic Work.....	183,200.00	15,000.00	25,000.00	28,400.00	25,000.00	25,000.00	35,000.00	23,900.00	360,500.00
Hydrographic Work.....	1,800.00	.....	.....	.....	.....	.....	.....	.....	1,800.00
Oklahoma:									
Topographic Work.....	14,000.00	.....	.....	1,000.00	1,000.00	1,000.00	1,000.00	.....	18,000.00
Oregon:									
Topographic Work.....	10,000.00	2,500.00	2,500.00	15,000.00	15,000.00	18,000.00	18,000.00	4,000.00	85,000.00
Hydrographic Work.....	15,000.00	2,500.00	2,500.00	13,419.47	7,470.00	10,000.00	11,000.00	7,300.00	69,189.47
Pennsylvania:									
Topographic Work.....	147,500.00	4,238.00	5,183.00	5,328.00	5,528.19	6,816.55	4,000.00	.....	178,593.74
Hydrographic Work.....	2,188.35	.....	.....	.....	.....	.....	.....	.....	2,188.35

¹ In addition to the amounts appearing in this statement, funds have been appropriated by states for cooperative geologic surveys, complete records of which are not available.

² Amounts in this column are taken from pamphlet entitled "Coöperation between the United States and Various States in Topographic, Hydrographic and Geologic Work," published by the Survey in 1910.

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STATE CONTRIBUTIONS: COOPERATIVE TOPOGRAPHIC AND HYDROGRAPHIC WORK¹—Continued.

States	Prior to June 30, 1909 ²	1909-10	1910-11	1911-12	1912-13	1913-14	1914-15	1915-16	Total
Rhode Island: Topographic Work.	\$5,000.00								\$5,000.00
Hydrographic Work.	1,800.00								1,800.00
South Dakota: Hydrographic Work.							\$960.00		960.00
Tennessee: Topographic Work.									4,250.00
Hydrographic Work.				\$718.22					718.22
TEXAS: Topographic Work.	5,000.00	\$20,000.00					35,000.00	\$35,000.00	95,000.00
Hydrographic Work.								8,500.00	8,500.00
Utah: Hydrographic Work.	2,950.00	2,000.00	2,000.00	2,521.47	\$2,000.00	\$5,500.00	4,100.00	5,015.00	26,086.47
Vermont: Topographic Work.						2,000.00	2,000.00	2,500.00	6,500.00
Hydrographic Work.		1,000.00	1,000.00	1,000.00	1,000.00	1,200.00	900.00	1,440.00	7,540.00
Virginia: Topographic Work.	1,750.00	1,750.00	1,750.00	4,250.00	4,250.00	4,250.00	4,500.00	4,500.00	27,000.00
Hydrographic Work.	987.56								987.56
Washington: Topographic Work.		10,000.00	12,500.00	13,750.00	13,750.00	12,500.00	11,500.00	11,500.00	85,500.00
Hydrographic Work.	6,150.00	5,000.00	5,000.00	4,419.31	4,200.00	5,000.00	5,950.00	6,020.00	41,739.31
West Virginia: Topographic Work.	117,000.00	15,000.00	12,000.00	12,000.00	12,000.00	14,331.41	6,758.20	7,639.39	196,729.00
Hydrographic Work.					132.00		400.00		532.00
Wisconsin: Topographic Work.							4,000.00		4,000.00
Hydrographic Work.	3,361.00					8,500.00	8,800.00	6,000.00	26,661.00
Wyoming: Hydrographic Work.				200.00	265.00		1,600.00	5,010.00	7,075.00
Hawaii: Topographic Work.			15,000.00	15,000.00	15,200.00	16,000.00	837.35		62,037.35
Hydrographic Work.			5,000.00	12,000.00	20,000.00	15,000.00	15,400.00	20,090.00	87,490.00
Total for both Topo- graphic and Hydro- graphic Work.	\$1,339,623.81	\$212,088.00	\$198,113.62	\$290,574.39	\$269,129.09	\$286,747.96	\$300,355.07	\$281,844.39	\$3,168,476.33
Total:									
Topographic Work.	\$1,121,869.00	\$159,238.00	\$148,983.00	\$177,853.00	\$161,267.09	\$179,047.96	\$186,800.07	\$166,789.39	\$2,301,847.51
Total:									
Hydrographic Work.	\$217,754.81	\$52,850.00	\$49,130.62	\$112,721.39	\$107,862.00	\$107,700.00	\$103,555.00	\$115,055.00	\$866,628.82

¹ In addition to the amounts appearing in this statement, funds have been appropriated by states for cooperative geologic surveys, complete records of which are not available.

² Amounts in this column are taken from pamphlet entitled "Coöperation between the United States and Various States in Topographic, Hydrographic and Geologic Work," published by the Survey in 1910.

APPENDIX 6

BIBLIOGRAPHY

EXPLANATORY NOTE

The bibliographies appended to the several monographs aim to list only those works which deal directly with the services to which they relate, their history, activities, organization, methods of business, problems, etc. They are intended primarily to meet the needs of those persons who desire to make a further study of the services from an administrative standpoint. They thus do not include the titles of publications of the services themselves, except in so far as they treat of the services, their work and problems. Nor do they include books or articles dealing merely with technical features, other than administrative, of the work of the services. In a few cases explanatory notes have been appended where it was thought they would aid in making known the character or value of the publication to which they relate.

After the completion of the series the bibliographies may be assembled and separately published as a Bibliography of the Administrative Branch of the National Government.

BIBLIOGRAPHY

UNITED STATES GEOLOGICAL SURVEY

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NOTE: Dashes at the beginning of an item indicate repetition of words in the preceding author entry. Thus, in item 6, the dashes indicate U. S. Geological survey.

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